(1)

Class PZ7
Book .F4958
Copyright No. Wca

COPYRIGHT DEPOSIT.

THE WONDER ISLAND BOYS

By ROGER T. FINLAY

Thrilling adventures by sea and land of two boys and an aged Professor who are cast away on an island with absolutely nothing but their clothing. By gradual and natural stages they succeed in constructing all forms of devices used in the mechanical arts and learn the scientific theories involved in every walk of life. These subjects are all treated in an incident and natural way in the progress of events, from the most fundamental standpoint without technicalities, and include every department of knowledge. Numerous illustrations accompany the text.

Two Thousand things every boy ought to know. Every page a romance. Every line a fact

---

Six titles—60 cents per volume

THE WONDER ISLAND BOYS
The Castaways

THE WONDER ISLAND BOYS
Exploring the Island

THE WONDER ISLAND BOYS
The Mysteries of the Caverns

THE WONDER ISLAND BOYS
The Tribesmen

THE WONDER ISLAND BOYS
The Capture and Pursuit

THE WONDER ISLAND BOYS
The Conquest of the Savages

PUBLISHED BY

THE NEW YORK BOOK COMPANY

147 Fourth Avenue New York

232
1418

THE WONDER ISLAND BOYS

THE CASTAWAYS

THE RAFT TO THE RESCUE

THE WONDER ISLAND BOYS

THE CASTAWAYS

BY

ROGER T. FINLAY

ILLUSTRATED

THE NEW YORK BOOK COMPANY

NEW YORK

PZ7
.F4958
Wca

Copyright, 1914, by
THE NEW YORK BOOK COMPANY

JUN -6 1914

©CLA376284

CONTENTS

I. The Tempest at Sea .....Page 11
The occupants of the life-boat. Harry's attempt to get medicine. The five days' storm. Washed into the sea. Disappearance of George. The object in the sea. Recovery of George. The breakers. Preparations for the struggle on the rocks. Striking the shore. The crushing of the boat. Thrown on the rocks. Disappearance of the boat. The night on the lonely rocks. Injury to George and the Professor. Harry's trip to land. Building a raft. Sailing the raft for the rescue. The tides.

II. Shipwrecked .....Page 29
George and Harry's home. Joining the training ship. The training ship *Investigator*. Voyage south. The Straits of Magellan. The Pacific. The explosion at sea. Shipwrecked. The open boat. The fury of the tempest. Illness of the Professor. Loss of the seaman. Their companions. Washed away.

III. The First Hour on the Island.....Page 37
The necessity of knives or cutting tools. Matches. Saltpeter. The quest for a home. Water supply. Springs. Why water comes out of the earth. Formation of the earth. Fallen-tree camp. Use for tumble weeds. Making a fire. Charcoal. Composition of explosives. Stone stove. Cooking and health. Rain clouds. Their origin. Wild potatoes found. Salt and vegetables. Distress signal. Half-masting. Observation Hill. Making observations.

IV. The Quest for Food .....Page 54
The theorist. The practical member of the party. Discovery of Brazil nuts. A grindstone. Why it cuts hard substances. The method of making stones round each

other. Clam-shell tools for cutting purposes. George's trip for food. Meeting with wild animals. Snakes. Lost on the Island. Harry's quest. Directions to Harry. Finding George. A peculiar weed. A mud-bank. Return home. Observing route. Determining directions. Landmarks. Bows and arrows. Clay. The ramie plant. Fiber. Hemp. Jute. Making clay reservoir. Impure water. Determining true north and south. Ascertaining foot measure. The metric system.

V. The Venomous Snakes .....Page 74
Floating objects; why they go ashore. Tides. Waves and their movements. Hard and soft water. Saponifying water. Treating ramie. Learning to use bow and arrow. Preparing for expedition into the island. Gathering provisions. Cord from ramie. Carrying provisions. The start. A westward course. Sago-palms. How prepared. Flour. Finding cassava tubers. Tapioca. Venomous snakes. Harry bitten. The Professor's remedy. Arrow-root. The wound treated. How to judge venomous snakes. The rattlesnake; the adder. Copper ore. The forest. Plums. Berries. Wild pear. Observations through the forest. Blazing the way. First use of their weapons. Discovery of yaks. The herd. Ground-hog. Woodchuck.

VI. The Combat Between the Bears.....Page 91
The clearing in the forest. The fight between wild animals. Discovery of the bears. The honey tree. The fierce combat. Death of one of the bears. Bearskin; bear's meat; honey. Preservation of the meat with honey. Curing meat with salt. Qualities of salt. Acquired habits. Potash and potash salts. Sea water. The salt rock. Copper samples. Putting metals to work. Blende. Zinc ore. Sulphur. Hunting new home. Discovering a river. A cataract. Coal. Returning home. Discovery of herd of yaks at their home. Capturing cow and calf. The vegetable soap. Milk from the yaks. Exciting experience with wild hog. The Aardvark. Making real soap. Soap cakes.

VII. The Discovery of Useful Metals.....Page 108
Preparing the new home. Difficulty in removing the yak. Building enclosure. Milking the yak. Novel method of taking the yak to new home. Accident. Description of the ropes and lariats. Escape of the yak. Installed in their new home. Return of the yak. Iron found. Making preparations to use ores found. Coal. Making charcoal. Clay furnace. Making coke. Fire brick. Common brick. Melting iron. Making forms for their tools. Castings. How they made cast iron and steel. Making a hammer. Making a grindstone. A hatchet. Making a bolo.

VIII. The First Exploration.....Page 129
The most useful tool. Putting up their new home. Clothing. Ramie fiber and the loom. The shuttle and the heddle. The weft and woof. Glue. The factory proposed. Making water wheel. The cataract power. Undershot wheel. Making nails. Installing water wheel. Making saw and frame. Annealing saw. Tempering it. Temperatures. How determined. Expedition proposed. Preparing for the journey. To explore the large river in the south. Building a boat. Description. Caulking. Method adopted. The blue flower found at Observation Hill. Flax. Ramie useless for caulking. Equipping the boat. Liberating the cow and calf before starting. Sail in the ocean to the mouth of South River. Entering the river. Caution observed. Perceptible increase in flow of current. Discovery of falls. Decision to leave boat at foot of falls. Measuring the height of falls. Triangulation methods of observation. Decision to ascend river bank on foot. Why forests do not come down to the ocean.

IX. Making Thermometers and Other Instruments....149
The first night's shelter. Primitive cutting tools. Unfamiliar sounds. Tramp of animals. Discovery of yak herd. Why animals avoid seashore. A path in the forest. Tracks not made by yaks. Following the path. Leaving the river. Shooting a hedgehog. How the

hedgehog played possum. Roasting the hedgehog. Discovering an orang-outan. How he weaves his seat. The climate. Comparisons with temperature of the northern zones. When the seasons begin. Differences between the east and west coasts. The Gulf streams in the Atlantic and Pacific. How modifies climate. Speed of ocean streams. Evidences of many varieties of wild animals. Altitude. Methods for determining. The mercury column. Weight of air, water, mercury. The Barometer. Characteristics of heat.

X. Signs of Savage Neighbors .....Page 157
The character of the landscape. Judging of land by the rivers. Origin of water, and what it tells. Mineral rocks. Discovery of new river. Following the river. Slow-flowing rivers. Course pursued in following a river. Finding a well-beaten path. Surprising discovery of remains of a fire. Evidences of human beings. Proof that savages made the fire. Determination to return to their home. Deductions and detective methods. How the savages made the fire. Building a raft to return on. Floating down the river. Finding footprints on the shore of the stream. Discovery of their former route. In sight of Observation Hill. Surprise at the disappearance of their pole and distress signal. Company at their home. Large herd of yaks.

XI. The Fight of the Yaks.....Page 167
Home again. Mystery of the missing flag and pole. At work on the factory building. Cutting and hauling wood. Putting up furnace for their ores. Making tools. Making a lathe. Preliminaries required. Making planes. A shaft. Brazing, and how they performed it. The flux used. Brass. The fight of the yaks on the cliffs. Killing of one of the yaks. Skinning the animal. Steak. Corned beef, and how prepared. Determination to tan the hide. Dehairing. Limestone required. Making lime. The limekiln. Burning it. Plaster of Paris; cement. Slaking the lime. Making a clay-lined vat for the hide. What causes the hair to be removed. The office of germs in dehairing.

XII. HARNESSING THE CATARACT .....Page 177

Why air is needed in making fire. Bellows and draft. The bearskin utilized. Making the water wheel operate bellows. The fine hair of the yak. How making of felt was discovered. Finishing. Making of hooks. Difficulty in tempering the hooks. A feast of fish. Kinds caught. Their method of making felt. Beating the hair to assimilate it. Fulling the felt, and what it means. Determining their position on the globe. Differences in determining latitude and longitude. Where calculated from. Degrees. What is meant by degree. Angles and their office. Showing that angle is not a measure. Position of a ship east and west determined in time, not in miles. Differences in lengths between longitudes at different points from the equator. Meaning of words latitude and longitude.

XIII. MAKING EXPLOSIVES .....Page 190

A refuse heap. How refuse and offal make useful things. Saltpeter. Niter. Uses. Making gunpowder. Explosive as a fuel. Why it explodes. Putting together the lathe. Making a drill. Suggestion to use yaks for team. Hunting for ripening seeds. Making a wagon. What was brought to the Cataract home. Medicines. Chemicals. Quinces. The legend connected with the quince. The hyacinth, hydrangea, and other flowers. Used as medicines, and their medicinal names and qualities. Nutting trips. The expedition. Hunting specimens of ore for the Professor. Tethering the animals. Disappearance of George. Harry's wild hunt. Failure. His hurried trip home on foot. Disappearance of the Professor. Search. Return of Harry toward the direction of the tethered team. A terrific explosion. Finding the Professor. The trip after George. The disappearance of the team. Discovery that George had the team. Finding George. The runaway of the yaks. Recovery of the yaks. George's story of the hole. Stunned by the fall. The brown substance on his clothing.

XIV. The Disappearance of the Boat.....Page 202
The Professor's questions about the hole. Its mystery. Asphaltum. Accidental discoveries and their value. The Professor's experiments in the hills. Determined to secure boat left at the fall. The trip of George and Harry. Disappearance of the boat. Speculations. Return of the boys. The Professor's questions about the boat and the oars; how placed and how left. Lessons of the mysterious occurrences. Advisability of making weapons. Caution against going singly into the interior. Harry's lathe completed. Making variety of drilling bits. Necessity for keeping time. Intervals of time. Clocks. Making a pendulum and determining its length. Latitude, altitude and temperature, all necessary. Making the first pistol. How they made the caps. How the copper was drawn into little cup-shaped forms. How the hammer of the pistol was made. The fulminate. The bullets without lead. Momentum. Its value in a projectile. Honey and sugar. The differences between them. Various foods on hand. Peculiar actions of the yaks. Harry and George following the yaks. Discovery of the barley fields. Exploring the beach west of the Cataract home. Finding piece of a wrecked boat. Shooting a partridge. A tree trunk in their water wheel. Why debris is cast on the seashore.

XV. Planning the Second Expedition.....Page 219
The daily life of the boys and the Professor. Their food; how found and prepared. Barley; its value as food, and universal use. Making a scythe. Hay-rack for their wagon. Trip to the barley fields. Cutting the barley. Capacity of their wagon. Ascertaining acreage. How to measure. A pound measure. The tonnage they cut. Making weighing machine. What their barley field yielded per acre. Experiments with their "guns." Contemplated expedition of discovery. Preparations. Weapons. Provisions. The wagon and team; how equipped. Making a millstone for the preparation of flour. Connecting it with their water wheel.

Grinding. Bolting the meal. Loosely woven ramie cloth as bolting cloth. Their kitchen utensils. Making a metal stove. Their team, Jack and Jill. Their training. The start for the interior. The weapons for the journey, and how arranged. How the wagon was equipped. Guiding the yaks with lines, like horses. Direction of their route. Their marching order, and preparations for defense. Into the unknown.

LIST OF ILLUSTRATIONS

The Raft to the Rescue ..... Frontispiece

PAGE

"George could restrain himself no longer, and he fitted an arrow to his bow" 102
"Put it closer to this side," said the Professor. "Do you see the footprints on the shore?" 166
"Before reaching home they saw George coming toward them in great excitement" 198
The First Home 41
The First Stove 45
Cirrus Clouds 46
Cumulus Clouds 47
Stratus Clouds 48
Finding the True North 72
Why Floating Objects Land 77
The Soap Plant 100
Ash Barrel 105
Leaching Lye 106
The Tethered Yak 110
Charcoal Furnace 115
Iron Smelter 121
Clay Bed Casting-Forms 123
The Original Hammer 125
The Bolo 127
The Shuttle 130
Threading the Heddle 131
Heddle Frame 132
Undershot Water-Wheel 135
Measuring Heights 144
What Degrees Mean 188
The First Gun 211
Cap-Making Die 212
Punches for Dies 213
Map of the Island 231

THE CASTAWAYS

CHAPTER I

THE TEMPEST AT SEA

"I AM afraid, George," said Harry, "the Professor will not last much longer."

"Probably, if we could reach the locker and get some of the medicine we might be able to revive him."

"I think it is too late, but we might try."

There is nothing more awe-inspiring than a tempest at sea. In every direction are lashing waves giving out their peculiar hissing sounds which are distinctly audible above the subdued and never-ending roar. The roar itself partakes of every form of moaning sound, rising and falling as the wind increases or decreases, and those who have experienced it in all its terrors—men who have gone through the greatest dangers on land, declare that nothing can excel the appalling fear which such a sight and fury of sound produces.

If this correctly describes the impressions of those on shipboard, who have every assurance of safety while the storm is raging, what must have been the feeling of those in the little craft who were tossed about in one of the fiercest storms which occurred several years ago.

"Does he still breathe?" said Harry.

"I cannot tell." Then, after a pause, "His heart still beats."

The little vessel was a lifeboat, or life buoy, such as are carried by steamships. It was less than sixteen feet long, but with a wide beam, as such boats usually have, and while practically unsinkable, was, nevertheless, liable at any moment to be torn asunder by the terrific impact of the waves. It had no spars or sails and only a single oar remained.

For five days and nights this boat had ridden at the mercy of the winds and the waves, and now the tempest had increased in fury, as though determined to wreak vengeance on the little vessel and its occupants.

"George, did you hear the old sailor say that death always comes to the sick when the storm is at its height?"

In the middle section of the boat were two boys and a man. The man was bearded and white-haired, lying on an improvised couch, across which was strapped a canvas cloth to hold him securely in place. His eyes were closed, and frequently he would turn his head from side to side. Sometimes a feeble moan would escape his lips.

At one side, and also securely lashed to the cross partition, were the two boys. One of them, Harry, was rather tall and spare of build, apparently about fifteen years of age. The other, George, was more stockily built, and about the same age.

Both were watching the old man, as it was practically impossible and manifestly useless to attempt to navigate the boat. During the five

days the boys, unused to navigation, had witnessed the death of three of their comrades, who had been swept away, so that at this time they knew their only safety lay in keeping a firm hold to the boat.

Everything about them was wet, and what few things were permitted to detach themselves were floating about in the water, and were it not for the cross partitions, the waters surging from end to end would have swept them to destruction long ago.

Without a word George, after the last remark, cautiously unfastened himself, and threw the rope over a cleat on the adjoining partition. The boat was violently thrown from side to side and at every leap of the waves huge volumes of water rushed in, first from one quarter, then from the other, and George's grim silence indicated that he knew the peril of his adventure.

"Wait," said the old man, "wait."

But George, if he heard, did not wait, as he crossed the partition and cautiously moved toward the stern of the boat.

All boats of this kind are equipped with food, put up in water-tight packages, as well as stimulants, medicine, and apparatus designed to aid the shipwrecked, and the boys knew where those articles were. The last bottle of medicine had been washed away during the night, and now that the hurricane was at its height no attempt had been made to secure another flask.

The gray hue of early morn began to show through the mist and spray which enveloped

them. It was just light enough so that Harry could see the face of the Professor, and he knew or felt that death was again about to visit them.

Before George started on his perilous journey he held out his hand to Harry. "Good-bye," was all he said, and turned his head away. Harry knew. Was it worth the risk? He leaned forward to stop George, but the latter did not heed him.

At that moment a terrific wave broke over the side, and George disappeared. Harry attempted to spring to his aid as soon as the sea of water had cleared the side, but being bound he could not afford any relief.

You may imagine the grief of the lonely boy, death on both sides of him, and his own end near. The angry waves, however, did not seem to terrify him longer. He had heard it said that the nearer death came the less frightful it really is; he now believed this to be true. His anxieties began to lessen and he became calm again after all these reflections passed over him, and he sat as one stupefied.

But he was awakened from his torpor by the sight of a human form, first here, then there, borne along by some mysterious force. It again awakened an interest in life. At that moment, by some fortune the body was thrown against the side of the boat where Harry sat, and he recognized the form of George.

Instantly life again became a reality. Before he could recover himself the next turn of the wave dashed him back, just as he saw George's

despairing hands arise from the waves. Harry disentangled himself, and, in spite of the rolling and pitching motion, crawled over the partition, to discover that a rope attached to the next partition had wound itself around a short staunchion and extended overboard. Not knowing why, he seized this rope and was astonished to find that something tugged and strained on it.

It flashed over his mind that the object might be George, so with the energy born of hope or despair, he began to drag it in. It appears that before George began his excursion toward the locker he tied the rope around his waist and attached the other end to a belaying cleat, and to this foresight he now owed his life.

George was still very much alive when, after several attempts, he reached the gunwale and was grasped by Harry; but the tremendous lurching and the avalanches of water hurled against him, to say nothing of the pitching and swaying motions, made his rescue a difficult task.

"You are safe," said Harry, and George, who up to this moment had exhibited the vigor of an athlete, fell unconscious into the watery pool within the boat. It was only by superhuman effort that Harry secured George and himself and placed him in such a position that he would not be strangled by the water.

In the meantime the moans of the Professor were plainly heard, and George opened his eyes, looking around in surprise at his situation. But Harry was not idle; as he was now the sole available crew, life took on another aspect to him.

Strange how these things will affect the human mind. A little while before, with death all around him and close to him, the prospect had no terrors. But now all that was changed and his fears returned to him.

He feared for himself; he was anxious for George, and the moans of the Professor startled him into renewed activity. He must provide the medicine for both his patients. After groping through the water, and the canvas, sails and rope which were now hopelessly entangled, he reached one of the lockers and succeeded in finding one of the collapsible flasks, and after making his position secure, had the satisfaction of reaching George and administering some of the medicine.

Without awaiting results, he struggled laboriously, between the pitching motions of the boat, as it mounted on the crests of the successive waves, to cross the partition and reach the Professor. He forced a quantity of liquid past his lips, and was finally rewarded by a smile of recognition and of thankfulness.

Daylight had come. Another day of gloom and misery to the mind of Harry, as he lay there panting from the excitement and the exertions.

"Don't you hear it—there it is—there it is!" It was the voice of George. He was leaning over the partition with one arm resting on the gunwale and the other arm extended, pointing forward. Harry looked, and could see nothing but the angry waves. "There it is," was again the

cry; but Harry was too excited to heed it. Was George delirious?

The Professor too heard it, and a smile lit up his countenance; but seeing Harry move toward George he feebly held out his hand and moaned, "Don't, don't, or you will be lost." Thus was mystery added to the perplexities of the situation.

What George saw was the mist and what the Professor heard was the unmistakable sound of breakers on a rocky shore.

The Professor had been a navigator in his early days, and he recognized that ominous sound which all mariners learn to fear. It is like an eruptive thunder which seems to come from below. It reverberates, not like aerial thunder, but somewhat resembling an unfinished moan, rising and falling at almost regular intervals. The roar of the breakers is not spasmodic, but is continuous and undulating in its character.

"See, Harry, see; the shore, the shore!" To Harry that sound and the meaning it conveyed were almost overpowering. Little did either of the boys know what dangers lurked in that rocky shore.

There may be risks in the tempests in the open sea, but they are mild in comparison with the perils which lurk on the battle line between the land and the sea. The Professor knew this, but he was powerless to help. When Harry reached George the latter had recovered.

"Now for the land! Let us get the oar and be sure to land the boat," said George, the while

tugging desperately with the rope which hampered him.

"Attach a rope to the oar; if we lose that we are lost!" Harry cried, who remembered that all their oars but one had been washed away, and the sole one was now in its keeper for use when needed. When Harry reached the oar he found it useless. That is, it was useless because the tremendous swells and lurches of the boat gave him no opportunity to use it effectively. The task was a hopeless one.

"It will do no good," he cried, and George, with his eyes strained to catch the sight of land, fell back like one in despair.

"Stop, stop!" cried the Professor, as he held up a warning hand. "Keep away, my boys; keep away." The boys looked at each other in amazement. Slowly they crossed the partition.

"Why shall we stop?" inquired George. The Professor grasped the boy's hand, and said: "We are approaching a shore where no one can with safety land or make a landing. Our only safety lies in keeping free of the coast. In a storm even a smooth beach is not a safe landing place excepting to those who are experienced. Keep off if possible until the storm abates; otherwise it is death."

The boys understood. Desperately they tried to keep the boat from the shore. They now noticed for the first time that the character of the boat's oscillation had changed. At regular intervals they were raised high as by a mighty billow and then sunk down into an enormous cavern.

The roar of the sea also had changed. When they went down into the abyss the swish and the bellow of the ocean was hushed, and a subterranean roar took its place. When they were poised on the pinnacle of the wave the great column of water striking the jagged sea line was like a discharge of heavy artillery in the distance.

"My boy, we must prepare for the end. We have gone in too close to change the destiny of the boat. When an object on the sea once gets within a certain distance of the land it will go ashore."

"But why?" said George. "What makes it do so? Is there a reason for it?"

"Yes, but we haven't time for that now. Our first duty is self-protection. I have no fear for myself, but I want to give you all the aid I can by my advice and suggestions. Never mind me. Take care of yourselves."

"WE won't leave you, Professor. Direct us what to do," said Harry.

"When the boat strikes the shore we may be fortunate enough to land when the wave which carries us is at its highest point. If such a landing can be made there is some hope of safety. If we do not strike the rocks during the time when the wave is moving in from the sea, there is still an opportunity, unless, while we are being carried back to sea again, we strike an obstruction. There would be no salvation in such a case. At best we have only one chance in a thousand."

"Well, we are going to fight for that single chance," said Harry.

"That is the proper spirit. Now make your

preparations at once. At the rate we are now progressing we shall be on the rocks in less than an hour. You will need strength for the trial, so get something to eat at once, and tie up a few necessary articles of food. Do not forget the water-bag. Then clothe yourselves in life-saving outfits, if you can reach them. Then, lastly, with the rope, harness yourselves together, because you will then be in a condition where each of you will know where the other is, and the presence of one will be a comfort to the other."

"But there will be three of us tied together, because I shall never consent to go without the Professor."

"Nor shall I," said Harry. "But how shall we attach this harness to the boat?"

"Do not attach it to the boat. The boat will be the most useless thing in the world to us if we once strike that shore. We are better off without it as company."

"Oh, I see why you wanted us to provide a bundle of provisions."

"Exactly so; and now tie yourselves and be ready."

The harness suggested by the Professor consisted merely of three strands of rope parallel with each other, and the ends tied together. The two boys and the Professor were securely lashed to the middle rope, so that the loops of the other two were free and the loops were carefully folded and ready to be thrown overboard at the proper moment. The provisions were also securely fixed to the inner rope.

These preparations were scarcely completed before a monstrous black rock passed them going to the shore.

"Do you know, boys, that we have already been on shore?"

"Why?" exclaimed both eagerly.

"Because the rock you thought was moving toward the shore was an illusion. We are simply moving out to sea. Do you remember whether we were going up or down when we passed the rock?"

"Oh, the rock came up right out of the water."

"Then we must have been going down. Now, we may land the next time, and if we can be caught by the crest of a wave——"

But his voice was lost as a column of water shot over the boat and by a violent upheaval turned it over, striking at the same instant a rock in its path that broke the forward part of the boat into fragments, and landed the seemingly uninjured part on a saddle in the rocks.

The only one who appeared to have any knowledge of the situation was Harry. Below him was George with blood streaming from a wound in his head. He was either dead or unconscious. The Professor lay near him, motionless.

Harry called to them, but there was no response, and before he could recover presence of mind to move, another wave swept over them and he found himself being dragged from the rock. This time the Professor had been carried up the rock so that he landed on the sloping side that faced the land, and the lodged boat was gone.

George was only partially stunned, but his scalp was laid bare and his left arm was useless.

"Are you hurt?" was the Professor's first inquiry. "And where is George?"

"Here I am," was the weak response.

"We must take advantage of things now. It seems we have a chance after all. Can we move higher up, and get a more sheltered spot? If so, I think we shall be safe for a time anyway."

"Thanks, Professor, for your idea of lashing us together. If you hadn't done that all of us would now be in the sea. Look how the loops of the rope have caught on the jagged edges of the rock."

"Quite true; while the rope is a safety device, it is also an element of danger. The boat happened to strike before we could throw the coils overboard, and it was only by the merest chance that they cleared the boat. If the coils hadn't cleared the boat we would be with it now, in all probability."

All through the day and long into the night they huddled together on a little piece of jutting rock, with the seething sea all around them, but as morning approached the area of their resting place grew larger and larger, and the Professor knew that the storm was going down and that the water, for this reason, was not piling up so high.

When morning came they could look out over a troubled sea, but while it was still angry and periodically sent in breakers, the wind had stilled, and as the sun came out and tried to soothe the waves they began to take courage and to speculate on their condition. For nearly seven days

our shipwrecked crew had not seen the sun, and it was, therefore, a most welcome sight.

The Professor was wonderfully cheerful. The weather became delightful as the day advanced, so that, though their territory was limited, they were comfortable. George, whose left arm had been strained, was not suffering very much pain, as the Professor had skillfully bandaged his arm and dressed the scalp wound.

"Well, boys, I suppose the next thing to do is to find a means to reach the land. This rock has been a good and substantial haven, but we must try this very day to reach land and see what we have before us."

"We can swim, anyway, even if our boat is gone, and with the aid of our life-preservers we can reach the shore, I am sure. But I suggest that as George has a useless arm I will first swim to land and form an exploring expedition on my own account," said Harry.

The Professor did not object, but he held back Harry, who was only too intent on starting.

"Never mind," said the latter, "for the present I am the captain of this expedition." Without further word he set about making the necessary preparations. He adjusted his life-preserver, and as soon as the Professor gave the word, went down to the water.

"Wait, Harry. Have you a knife or anything to defend yourself with, or with which you may be able to prepare some article of defense?" To the consternation of all there was not a knife in the party.

"I am going anyhow."

"But, Harry, you must take a piece of this rope along. You may find it of great service." To sever it was a difficult matter, but the sharp rock and a little patience overcame the difficulty, and with the sling of rope over his shoulder and secured around his waist, he entered the water. Avoiding the rocks as he swam, he finally reached the last stretch of rock which lined the shore.

Before starting they had agreed upon a system of signals, and had selected the signaling point on land which Harry was to use as his station. He next directed his steps to this point.

But now for the first time Harry began to feel the sensation of fear. He was treading an unknown land, but there was too much pride in him to turn back, so he cautiously stole forward and carefully picked his way along the rugged rocks and entered a small ravine which led upwardly until he reached the open ground. He made his way toward a small clump of bushes, and beyond, in the distance, he could see a forest. What to do, or which direction to take, was the question for him to decide. For the time being he was lost; something oppressed him. It was the silence to which he was not accustomed, but there was the glory of seeing and treading land, and feeling the warm sunshine after escaping the terror of the seas.

He could see no signs of human habitation. In the distance to his left was the rolling sea, and he soon began to realize that he must endeavor

to find some means, if possible, to rescue his companions before the night set in.

It seems that their landing place was part of a projecting point of land, one side of which appeared to be a rocky coast line, and the other side comparatively free and open, and which promised rather easy access to the sea.

He determined to explore the accessible side, and soon found himself close to the beach. Here, scattered in all directions, lay driftwood, bark, and seaweed, and without waiting to rest he began to gather a mass of material, which he deposited near the shore. The wisdom of the Professor's advice about the rope was now apparent to him.

When he had gathered enough wood to form his primitive raft the lack of any knife or cutting implement dawned on him. There were no rocks near to aid him in cutting the firm marine rope. Quite by accident he picked up a clam shell. He knew that a broken edge of shell would render him service, but how to break it was the question. Finally, after numerous experiments, he succeeded in breaking one of the shells by using two pieces of hard driftwood. With this newly acquired tool he finally cut off several lengths by means of which he bound together three bunches of wood. After dragging them to the water's edge he launched them singly, and when he had floated them, tied them together.

It was fortunate for the boy that this launching was effected in a small bay or cove, for the swells were still coming in at regular intervals,

and if he had attempted the launching at the open sea front, his craft might have been wrecked. With another piece of rope he fastened flat pieces of bark to a pole, and thus equipped, he fearlessly piloted the raft into the open sea, cautiously working his way around the point in the direction of the rocks where his companions lay.

The Professor and George saw Harry disappear with many misgivings, and anxiously awaited his return from the point of disappearance. An hour passed, then another, and no signal, and anxiety gave way to fears.

"If the land is inhabited I can understand the long silence, as it may take some time for him to arrange for our delivery. On the other hand, he may be a prisoner, in the hands of savages."

"But, surely, if he intended to save us, or was in a condition to do so, he should have signaled us as agreed."

"The only other alternative is that he may have met with an accident. Unfortunately, my long illness has kept me entirely out of touch with our location. We are, no doubt, in the Pacific Ocean, and south of the Equator."

"How do you know we are south of the Equator, Professor?"

"The sun tells me that."

"How does it tell you?"

"Because, you will remember, it is summer here at the same time they have winter north of the Equator. We left New York in September, and we have been cruising about three months, so that it is now December. North of the Equator the

sun at midday casts a shadow to the north; south of the Equator it casts a shadow to the south at the same time. In the winter——"

"Ship ahoy!" rang out like a challenge, as the amateur mariner Harry appeared coasting along the rocky edge. George sprang forward so impetuously that before he could check himself he was precipitated into the water. Fortunately, it was not deep or dangerous, and the only serious feature was the possible injury to his strained arm.

"I shall have to commission you the Admiral of this Empire," said the Professor. "You are a wonder to construct and navigate such a craft. It is, indeed, lucky that the tide is ebbing or you never could have accomplished it."

"Was that the reason, Professor, you held me back for two hours this morning when I was so anxious to start?"

"Yes, because at that time the tide was still going too strong toward the land, and I knew that your time of safety for returning would be just after the ebb tide ceased."

"What is ebb tide?"

"I am glad you asked that question. Tidal movements in the ocean depend on the attractive power of the moon. The moon revolves around the earth in less than twenty-four hours, hence there are two tidal movements during that period; namely, high tide and low tide. When the tide is at its highest and the waters begin to creep down the shore line, the tide ebbs, as it is called, and just before the return or the flood time commences the ebb tide ceases. So you launched your

ship just before the ebb tide ceased. But now we have business to carry out. What did you discover? Is the island inhabited?"

"I could not find any signs of human beings, although I hadn't time to go very far, as I was so anxious about you, and it was too far for me to go back to our signal station."

"The tide is just right for us if we lose no time, so let us start at once."

"Let us get the Professor aboard first, and then George can take a place. If our ship won't hold all of us I can swim it."

"But," said George, "who will row, because my arm is useless?"

Harry had not thought of this.

"You forget," said the Professor, "that the flood tide is now coming. We cannot, then, be carried out to sea, and we shall, sooner or later, probably within the next hour, reach the landing place."

The raft, although much submerged, was fairly comfortable, and by careful management was finally piloted safely around the rocky point and landed on the beach not far from the place where Harry had launched the craft.

CHAPTER II

SHIPWRECKED

Having rescued our young friends and their elderly companion from the dangers of the sea, we will leave them on the island temporarily, in order to explain how they chanced to be where we found them, and relate the incidents leading up to their narrow escape.

George Mayfield and Harry Crandall were ordinary boys. Neither had distinguished himself at the country schools which they attended, prior to their advancement to the city graded schools, and where for the first time they met each other.

Harry's uncle was an importer and interested in a fleet of trading vessels, and when a movement was set on foot to man a small ship to be used as a training ship for boys, the uncle made an application in behalf of his nephew for a position. It was eagerly accepted by Harry provided George could also accompany him.

George's parents reluctantly consented; and so it happened that early in September the boys landed in New York, and were conducted by their friends to the dock in South Brooklyn, where the *Investigator,* the training ship, was docked.

It is needless to describe the advices, the admonitions and the final good-byes which were uttered. There is always more or less joy and sorrow blended in these partings, and it may be

imagined that George and Harry, like all boys, found more joy in the excitement of the hour, than sorrow at the separation.

It is a peculiar phase of human nature, that those who are left behind always feel the separation more keenly than those who are taking the trip. There is more or less exultation in the traveler at the thought of adventure—of seeing new places and things which, temporarily, suppresses the instincts for home.

The boys marveled at the new and strange sights which engaged their attention as they slowly sailed down the bay, past Governors Island, the Statue of Liberty, and through the Narrows, with old Fort Hamilton on one side and Fort Wadsworth on the other.

Reaching the lower bay they passed innumerable fishermen and incoming vessels from foreign ports, and within an hour after leaving the Narrows they were abreast Sandy Hook, which is called the gateway to the harbor.

Soon they were in the open sea and now, for the first time, they had an opportunity to look around and note the character of the vessel which was to be their home.

The vessel was a small, staunch ship, 180 feet long and 30 feet wide, and was equipped with a 650-horse-power engine, turning a single screw, so that while not designed for speed, it could readily make from twelve to fifteen miles an hour.

It was fitted up with all conveniences for comfort, and especially adapted for its new uses, to care for, drill, and educate the boys who were

committed to its keeping. Three fair-sized class-rooms had been provided below the main deck, and on the main deck were a gymnasium, library and assembly rooms, and cabins for the boys.

The crew occupied quarters on the lower deck, and aft were the kitchen and dining-room.

The boys learned that they had forty-three companions, ranging from 14 to 18 years of age, all handsome, intelligent young men, many of whom, no doubt, looked upon the adventure as a lark.

To George and Harry, unaccustomed as they were to sea life, everything was interesting and instructive. Early in the morning of the first day they were all called to quarters, as it is termed in marine parlance.

This is an assemblage of men and officers, at which time they are directed in their duties, instructions are given, or men are reprimanded or rewarded. Here the course of study and of life on shipboard was explained, the rules and regulations of the sea were read over, the hour for retiring and the time for rising were set, meal times regulated, hours for recreation provided, the character of the exercises prescribed, and almost every detail of life and action specified.

It is the fundamental principle of such training schools to cultivate the formation of regular, healthful and beneficial habits, and to teach the boys not only what to study, but how to acquire knowledge, and this latter requirement, "How to do it," is of far more importance than learning what to study.

It is needless to the purpose of this book to

detail life on shipboard; how the course of the ship carried them to southern ports, passing Cuba, thence through the Caribbean Sea. After leaving Buenos Aires, the seaport capital of the Argentine Republic, they set out on their long sail for the Straits of Magellan, the short cut to the Pacific Ocean.

It may be said that those days were busy ones. They acquired the uses of tools and implements of all kinds, for the training school on shipboard is not for nautical purposes alone, but to instil a general education. In physical exercises rowing is necessarily one of the first accomplishments, and both of the boys became apt pupils, receiving many opportunities for practice while in the different ports.

They were of an inquisitive turn of mind, and gradually attracted the attention of the old Professor who had charge of the science department. Professor Chapman was an exceptional scholar and a practical instructor. He was a man of profound learning and had a wide experience which admirably fitted him for his position. He was like the sages of old, who loved knowledge for its own sake and truth because of its merits. Like a true scientist he believed that education is the greatest blessing that man can enjoy. He was an inspiration to the boys, and although George and Harry exhibited peculiarly strong and divergent inclinations in their methods of study, as we shall presently see, the Professor never indicated a preference for either on this account.

The passage of the Straits was an event on

shipboard. The air was delightfully warm and midsummer in southern latitudes was at hand. They had left New York on the 20th of September, so that now, after nearly two months of cruising, the warm November days were at hand. How odd to talk about warm weather in November, December, and January, when nearly everybody at home is freezing!

Slowly the ship steamed to the west, and finally altered its course northerly. Two weeks before the ship passed the Straits, the Professor had been taken ill, so that for nearly three weeks he was not on duty. His former exhibition of affection for the boys made them crave the right to visit him, which they did at all times when permitted. Thus they cemented a friendship which laid the foundations of the present series of books, detailing their adventures, not only through perils and difficulties on land and on sea, but through the realms of knowledge concerning things which every boy should know.

One night while the boys were making their regular visit there was an unusual commotion on board, followed immediately by a terrific explosion which shook every part of the ship. Harry was the first to recover himself.

"What is that? Do you suppose we have struck something?"

"No," said the Professor. "That sounds like an explosion."

George rushed from the room, and Harry turned to go, but the Professor restrained him.

"George will come back with the news. We may have to devise means for our safety."

But the news came all too fast. An explosion, not explainable, had torn the ship apart and she was even then sinking. There was commotion everywhere. Harsh orders came from the officers, and the rushing, tearing scramble of a disorganized mass reached the sick room.

George burst in crying, "She is sinking, and we must take to the boats." Without knowing how or why, the boys rushed out to the deck alongside the Professor's room, and with two other boys prepared one of the lifeboats for launching, a task which, fortunately, they learned as one of their duties.

The explosion had practically severed the ship into two parts, so that the work of rescuing was greatly hampered, as the entire ship's company was now disorganized. It was only too plain that if they were to be saved they could not depend upon orders, and in this the Professor agreed. He was very weak, but under the excitement of the moment, with the aid of the boys, he was landed in the boat with George, Harry, a seaman, and two boy companions, making a total of six.

When it was found that no one else needed assistance, and the wreck was practically cleared of all its human occupants, they cut loose from the ship, and not a moment too soon. Even at the distance they then were from the ship—less than two hundred feet, when it sank—the wave which engulfed the *Investigator* rocked their boat.

They were on the open sea! True, they had a

lifeboat, supposed to be unsinkable, but it was night and they had no knowledge of their position, as the Professor's illness deprived him of the necessity and opportunity for knowing, and the seaman did not possess the knowledge necessary to aid them.

Only one of the other lifeboats had been in sight since the ship went down, and to that the seaman directed the course of the craft, only to learn that there was not an officer aboard. It was agreed, however, to stand by so as to render assistance to each other when morning came. Nothing else could be done because the Professor was exhausted and utterly unable to give any directions.

A light wind had been blowing, and had increased when the catastrophe took place, and it now became a gale. It was impossible to keep the companion boat in sight, and before long the single sail they carried was taken in. The wind and the waves increased, and a terrific storm of thunder and lightning followed. During the height of the storm something struck the little vessel a violent blow, and when the lightning again lit up the view George and Harry saw only a single comrade, the seaman and their other companion having disappeared, and with them the oars which they held.

All that night and the next day the storm kept up its vigor until all were exhausted. On the third their other companion was washed overboard, despite the efforts to rescue him. Long before this they had learned the wisdom of lash-

ing themselves securely to the boat, and they never could account for the reason why their companion should have been hurled into the sea, except that in his delirium he may have untied himself and deliberately cast himself overboard.

Two days and two nights more bring us to the opening scene of the first chapter.

CHAPTER III

THE FIRST HOME ON THE ISLAND

"HERE is our empire," said George.

"But of what use is an empire without a knife or a match?" was Harry's response.

"Did nature make knives or matches?" asked the Professor.

"Of course not. I made a pretty good knife out of a clam shell that nature furnished."

"Then why not make matches?"

"Certainly, if nature will furnish me the materials."

"Here it is, all about you; the earth, the rocks and the trees."

"Well, we must have a fire."

"Not now, boys; we need something else first. The first necessity is food. We have very little of that left, not enough for another meal. Then there is another thing we need more than a fire."

"I know, shelter."

"Yes, and something else you haven't mentioned."

"Why, clothing, to be sure."

"As we happen to have a sufficient supply of clothing, and are not starving, let us, first, select our habitation, and then we can arrange our fuel supply."

"Why not take some of these clams along? The sea owes us a living."

"Well said, George." So gathering up a quantity, which George insisted on carrying, by converting his jacket into a carrying bag, they started for their "empire." Harry assisted the Professor, who, though very weak, was able to walk with the assistance offered.

They directed their course toward the forest which Harry had discovered, and to the right they found the ground uneven and broken. Here the Professor suggested that the probability of a safe retreat would be more likely in that direction than in the open. In their journey they were gratified to find vegetables of various kinds, but did not stop to investigate their character, as a home was the first consideration at that time.

The quest for shelter was a tedious one, and George suggested they camp for the night where they were, but the warning voice of the Professor, that they had but little fresh water left, induced them to proceed.

"The hills will also, doubtless, furnish us a water supply," he added, "and as a last resort we may be able to find a spring along the rocks, as I judge they are of such formation as to yield a supply."

"Why should the rocks furnish a water supply?" asked George.

"The rocks are merely the mediums which convey the water from place to place."

"But I have seen springs come up out of the ground where there were no rocks."

"That was an excellent observation. You may, probably, know the reason why."

"Because the earth itself holds water."

"Yes, but why should it come up out of the earth?"

The boys were silent.

"I will tell you. When water oozes from the earth, or from the rocks, it is because it is supplied from a source which is higher than the spring itself. That source may be a mile, or many miles away, and it is conveyed through the fissures of the rock until it comes out at the spring."

"But suppose there are no rocks near the spring, how does it happen that the water comes up?"

"The earth itself is made up of formations which may be purely sand or loam. In that case the sand or loam absorbs the water, and springs are not formed. The only remedy, then, is to dig a well and the water then flows into the well from the surrounding moist soil. But where the springs do come up out of the ground there is generally a clay or shale formation, usually in layers, which carries the water along just like the seams in the rock."

"What is this?" said Harry, as they descended the hill. "Here is water."

"There must be a spring near this," said the Professor, and they eagerly passed up along the little stream. The appearance of a spring trickling from a little ledge of rock was a welcome sight to all.

"Now for our camp," said George.

The Professor pointed to a fallen tree less than two hundred feet away. On examination it was found to be a large one that had been blown down

during the storm, and the roots had carried up quite a quantity of earth, which would make an excellent shield or wall for one side at least.

Harry was all energy now. He gathered a quantity of small poles, such as he could easily break, as well as a number of smaller ones with the leaves on them, and together they made a crude enclosure below the fallen trunk. This work occupied their attention until the sun had nearly gone down behind the hills, so the Professor suggested that rest was now of more importance than anything else after the hard day's work.

"We haven't made our beds yet," said Harry, as he darted in the direction of the woods. Within a short time he was back with a quantity of leaves.

"Why didn't we bring the rope with us?" said George; "we might have made a drag to haul in the leaves with it."

"Our coats will help us out." So George accompanied Harry several trips, and within a half-hour they not only secured sufficient leaves to make the Professor comfortable in a thickly matted bed, but had their own "bunks" well fitted out for their first night's experience.

When they went out for their last load the Professor suggested that they should bring in a few stones and also some dry twigs.

"Didn't we see some tumble weeds clogged up against some underbrush as we came along? That, or any small leaves or dried-up vegetation, will come in handy."

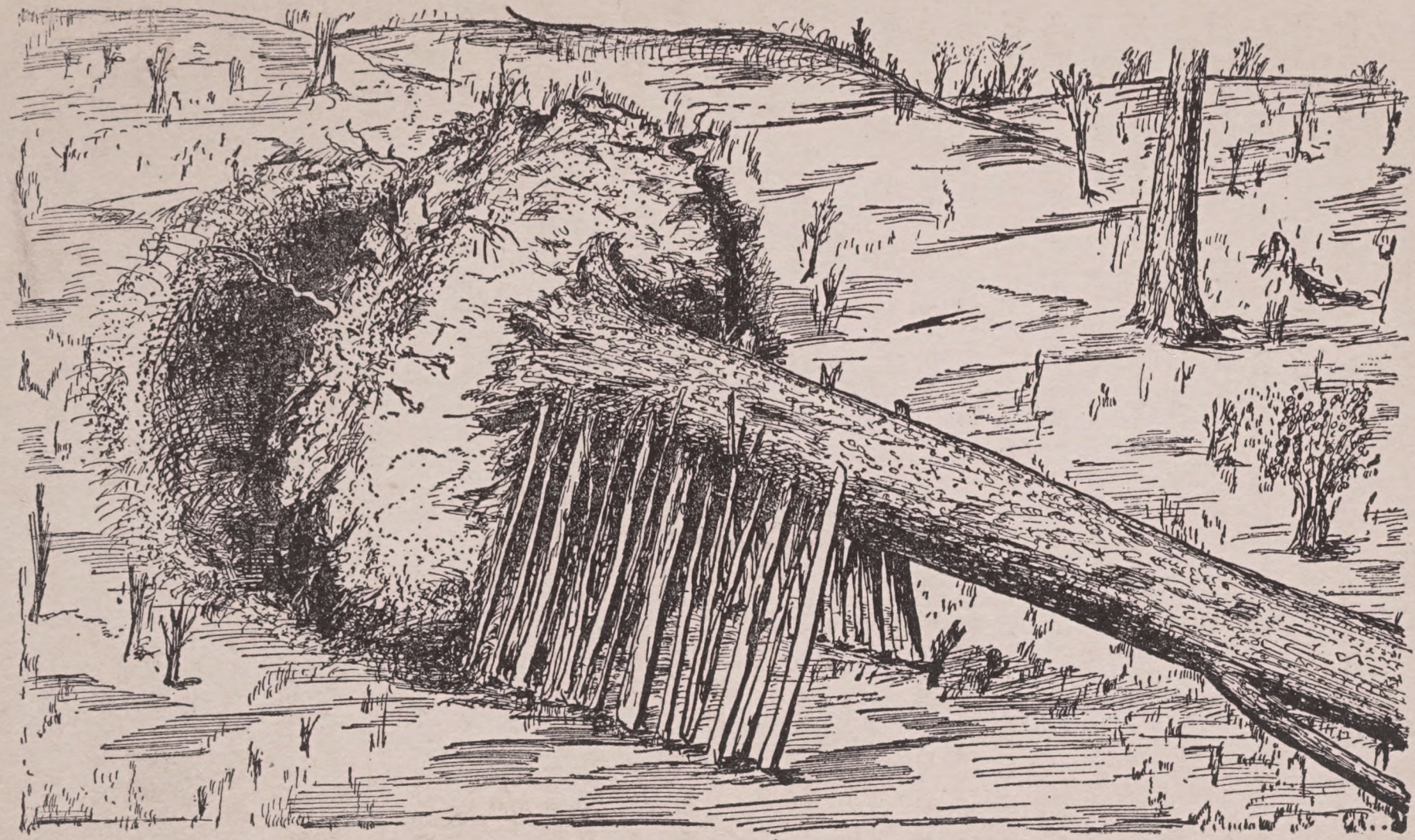


Fig. 1.

"I know what you mean. I can get plenty of that."

The boys willingly obeyed.

"Now for a feast, boys; I begin to feel hungry, after my hard work to-day," said their adviser, with a twinkle in his eye.

"Never mind, Professor. If you will only direct us it will give us pleasure to do the work."

"Then supposing we have baked clams for our first course to-night."

Both boys burst into laughter. "Let us have the matches, Professor."

"I saw Harry bring them in a little while ago. Where did you put them?"

There was a look of bewilderment in Harry's face, until he saw the Professor's eyes wander toward the dry sticks. He quickly handed one of them to the Professor.

"You must have made a mistake. This is of no use as a means to build a fire."

It was George's turn to laugh.

"The very word 'matches' means the origin of the word. A match is what I wanted for the piece you handed me. It really signifies that to produce heat, whether mechanically, electrically or chemically, two elements, substances, or bodies, must be used together."

"Oh, yes, I know, by friction."

"Yes, that is the mechanical means."

"But do matches produce fire by mechanical means?"

"Yes, combined with chemical means."

"Then, chemical and mechanical means must be used together?"

"Not at all. One of the matches made in the early part of the last century was in the form of a stick of wood tipped with sulphur, which was dipped into a bottle of phosphorus. The chemical action was hot enough to ignite the sulphur. But it was inconvenient and dangerous to carry around phosphorus, as it burns at a very low temperature. Sulphur burns at a higher temperature, and wood at a still higher temperature. Instead of that inconvenient method the practice now is to combine the sulphur and phosphorus and tip the end of the match with that, and then use friction or mechanical means to produce the low or initial heat to ignite the phosphorus; the phosphorus ignites the sulphur, and the sulphur ignites the wood."

"But how is it that some matches will not ignite unless they are scratched on the box?"

"Because the substance on the box has in it such material that it ignites at a low temperature, like phosphorus, and the match itself does not have a low igniting material."

In order to utilize the two sticks, one is held rigid and the other is forcibly rubbed against it over the same area, and by that means a sufficient heat is produced to make sparks."

It was here that Harry's strong arm came into play.

"Now, when you see the sticks begin to smoke, bring some of the dry and fine leaves near it, but keep up the rubbing." Harry did so, and to

his delight the smoke soon started, and finally, at each rubbing motion small sparks appeared, blacking the surfaces of the sticks.

"That black you see is charcoal, or carbon, and it is the greatest fuel known."

"If it is such a good fuel why use the dried leaves?"

"Because to light a fire and maintain it requires oxygen. Neither carbon nor hydrogen will burn in the absence of oxygen. One-fifth of common air is oxygen. Air surrounds the small leaf filaments so that the sparks from the wood will get sufficient oxygen to start the blaze, whereas that same amount of air would not start fire in the sticks themselves."

"But if air is absolutely necessary to make the fire, how does it come that powder if packed in tight, so that no air can reach it, will burn?"

"Because all explosives have sufficient oxygen combined in their make-up to support combustion. That is a matter we shall have to take up more fully at some future time, because it is a subject of vast importance and will be of immense use to us to understand." At this rate, however, we shall have a late supper."

With a little nursing the fire was fairly started, and soon was ready for the stove.

"Now for our stove. Here are the stones. I had quite forgotten what they were for."

"Can't we make some other use of them?" said the Professor.

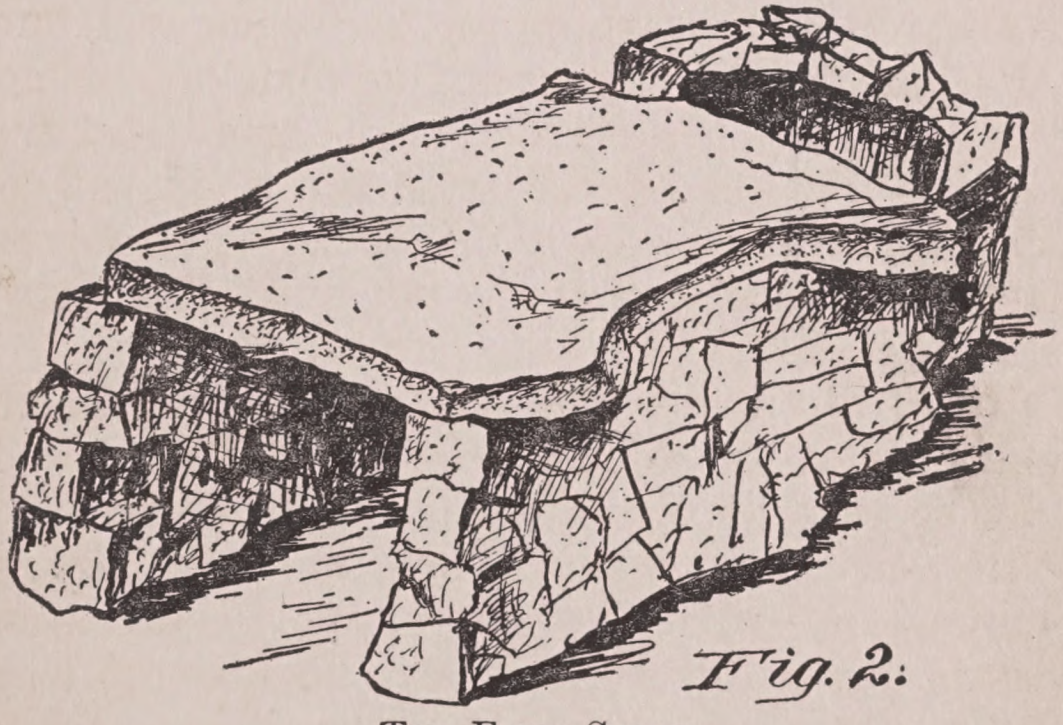
"Why, we can use them to open our clams, as I suppose we shall want them on the half shell."

"If we roast them whole there will be no trouble in opening them."

"Why?"

"Because the heat destroys the ligament which holds the shells together."

A fire was soon blazing in the stove, and the clams scattered over the stone top, and also a goodly quantity was put into the glowing fire, so



THE FIRST STOVE

that in a short time the clams forgot to be so close-fisted and opened up their treasure.

It was, indeed, a feast to our mariners after the stress and privations of the past week.

"Do you know that it is now eight days since we have tasted anything warm?" said George.

"But I am thankful," said Harry, "that the Professor has been able to survive and really almost to recover his strength during the past eight days."

"It only shows," said the Professor, "that cooking or high living are not the things which nature really needs, if she needs any aids. Man is just as liable, in his ignorance of the proper remedies, to fight against nature, as to aid her. I am particularly thankful for the bravery, the kindness and the helpfulness of my two young friends. If my strength permits I am going to prove to you that the shipwreck will be a blessing to you, and your trials the very stimulus which will aid in

Fig. 3.

CIRRUS CLOUDS

making you strong, self-reliant and unselfish men."

The boys were deeply affected by their friend's words, and assured him that their earnest desire was to merit his friendship and affection.

The clams were greatly relished, and while they had no other provisions they retired for the night contented and satisfied and in keen anticipation of what the new day held for them.

The following morning opened with a hidden sun. Heavy clouds were moving westwardly, and indications pointed to rain.

"Yes," said the Professor, "those are rain clouds."

"What are the rain clouds?"

"All clouds are really rain clouds, in the sense that clouds are merely minute particles of water

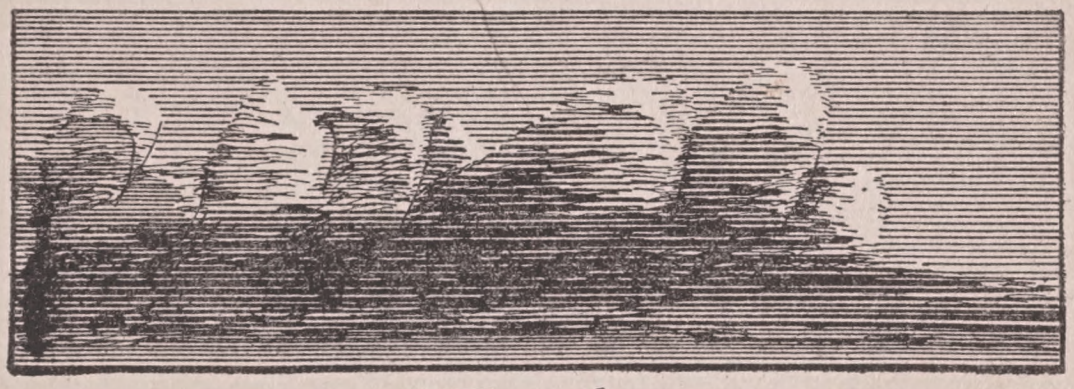


Fig. 4.

CUMULUS CLOUDS

held in suspension. The meteorological name for a rain cloud is called 'nimbus.'"

"I thought nimbus was the halo, or whatever it is called, that surrounds the head of Christ in pictures?"

"So it is. It means a cloud or mist. In ancient times the nimbus of God was represented as of triangular form. The nimbus of Christ was in the form of a cross; that of the Virgin Mary as a plain circle; and that of the angels and saints as made up of a circlet of small stars."

"But the pictures all show the nimbus with rays branching out in all directions. I don't see how the clouds do this."

"Then you have not carefully studied them. There are three kinds of cloud which go to make up the true nimbus, or rain cloud. One called the

cirrus, or the cat-tail cloud of the sailors (Figure 3), which looks something like the branches of a fallen tree. These clouds move at great heights; the cumulus clouds (Figure 4) are dense masses, either convex or rounded at their tops, light at their upper edges, and having dark bases. They look like black smoke with illuminated tops; and, third, the stratus (Figure 5), which are in the shape of long parallel masses, like long bands.

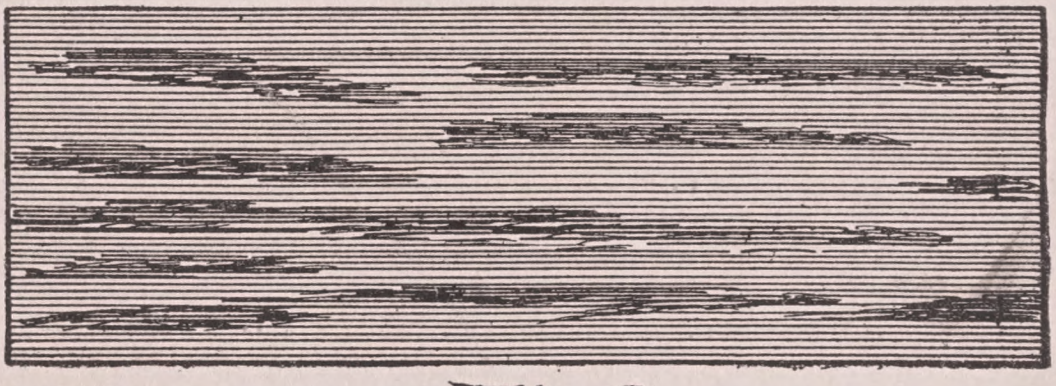


Fig. 5.

STRATUS CLOUDS

You can see the sky between them. When these three forms merge, or become joined with each other, the true nimbus is formed and rain falls. I have no doubt water is falling there now," he said, pointing toward the west.

"If that's so," said Harry, "we ought to put a better roof on our house as quickly as we can."

"I vote that we get something to eat," said George. "Clams are good, so far as they go, but I want something else for a change."

"George is right; we can, probably, get along fairly comfortably for another day as we are, but food is absolutely necessary."

"I will go for some more clams," said George,

"and on my way back try to forage for something else."

"I will have the fire ready by the time you return," said Harry. It did not take George long to reach the beach. Great was his disappointment to find that the tide was now in and the water had crawled up far beyond their landing point, so that no clams were in sight. He was also chagrined to find that the log raft had disappeared, and with it the rope and the life-preservers which had been left there.

This piece of news was too much for George, who at once returned breathlessly to the camp, to impart the unfortunate information. The roaring fire but added to his vexation.

"Probably you would better try the garden," said the Professor. "I saw some good substitutes, if I am not mistaken, for some of our northern vegetables; and you may at least find some greens that will be relished. I shouldn't be surprised to find that our farm contains many varieties, and also berries. Possibly we may find the plaintain tree."

"I'll make an effort at least to get something. I'm too hungry to wait for the tide," said George, who requested Harry to break off and sharpen a stick for him, so that he could have some sort of tool, at least, and with that, singing merrily, he was off.

He had a long quest for a hungry boy. Too long, he thought, but he persevered. Finally, after digging up one vegetable after another, only to throw it away in disgust, he uncovered a vine-

like plant, to the roots of which adhered small egg-shaped bulbs, each stem carrying a dozen or more of the tubers. On crushing one of them he found the odor not unlike the potato, but it was very bitter.

Out of breath he hurried to the camp, with a number of specimens, to show the Professor.

"What are these? I found a lot of them, but they are very bitter, and I am afraid they aren't good to eat."

"Well, isn't a raw potato rather bitter? You were very fortunate, indeed, to discover this kind at the first attempt."

"What is it?" asked Harry.

"It is a wild potato, called the solanum Jamesii, one of the six well-known varieties of the potato. In botany the potato is known as solanum. This variety grows on the mountains of Colorado, New Mexico, and in many parts of South America."

"Do these wild potatoes grow everywhere?"

"No, but they have been found in different parts of the world; in the United States, Peru, Bolivia, Ecuador, Colombia, Costa Rica, Mexico, Chili, in the Western Hemisphere; and in Italy, Spain, and Germany in the Eastern Hemisphere."

Harry had built a very substantial stone stove, and covered it with a flat stone which he found on the hillside.

George's delight knew no bounds as he hurried to gather more of the tubers, repeating the newly found name, solanum, over and over. It was his first lesson in botany.

This variety of potato, although much stronger

in flavor, and more unpalatable in its raw state than the cultivated potato, is much sweeter when baked, but it is not as tasty when boiled. The potatoes were placed on the heated stone and covered with a bridge of small stones to keep in the heat. It was really a treat.

"How sweet they are. When I tasted them raw they were bitter. Why is it that cooking makes them sweet?"

"Because potatoes contain phosphoric acid and nitrogen, as well as other acids. Nitric acid is formed, which we taste, and also the phosphoric acid. Heat destroys the acids, or, to be more exact, as over seventy-five per cent. of the potato is water, the heat converts the water into steam, and also at the same time liberates the salt, which the potato also contains, so that when the salt and the acid combine a neutral compound is formed. Some varieties of potatoes have as high as five per cent. of sugar, as well."

"But why should salt destroy the acids?"

"Salt is the opposite of an acid, and when they meet there is a fight in which both are overcome, and the result is a new compound unlike either of the originals."

The meal finished, their conversation led toward an inquiry as to their location. To be cast upon an island, far into the unknown, has been the lot of many, and the first instinct is a cry for help. It was so with our adventurers.

"This may be a small uncharted island, or we may have landed on a coast in the path of ocean

vessels. In either case our first duty is to put up a distress signal," said the Professor.

"How is the distress signal made?"

"Usually by inverting the flag."

"But we haven't any flag," said George, and after a moment's reflection, "I will use my shirt if you can make a flag out of it."

"But," responded Harry, "how can we make a flag unless we have the colored stripes and the blue square at the upper corner? If we don't make such a flag how will they know it is upside down?"

"By half-masting the flag."

"Oh, yes, I remember, while at Rio Janeiro, the captain ordered the flag run up halfway on the staff, on account of the death of some one."

After some hours spent in finding a suitable branch of a dead tree, and laboriously ridding it of the twigs and branches, the improvised flag was tied to the pole midway between its ends, and carried to the highest point. A hole was hollowed out, to receive the pole, and stone was built up around it to hold it in position.

Thereafter the daily, if not hourly practice, unless they were too busy, was to make a pilgrimage to Observation Hill, as they called it.

During the next few days they made several short journeys a few miles inland, and it was their custom at all times while they were on these tours to take mental notes of everything they saw which was new or out of the ordinary. The Professor cultivated the habit of observing even the smallest things; the formation, shape and color of the

rocks; the inclination and direction of the hills; the character of the soil; the particular growths, such as vegetables, shrubs, flowers and trees; the birds, their plumage; insects and other living specimens, and he endeavored to instil this not by direct efforts, but by way of their own intuitions, as the needs and the requirements of their daily life demanded.

Returning from Observation Hill on one occasion George took particular pains to gather a large bouquet of flowers, principally a species of the white daisy, and a yellow flower, not unlike many of those found in the fields all over the United States. One blue flower, very small, of which each stem carried quite a cluster, particularly attracted his attention, and the bouquet was largely made up of this variety.

"This is something we ought to use as a centerpiece for the table of our dining-room," said George, with a sly smile.

The Professor said nothing about the blue flower.

CHAPTER IV

THE QUEST FOR FOOD

The following day a council was called. The Professor was regaining strength and George's wounds were mending, so that it was concluded, after full consideration, that before making further explorations, or running any risks, the home should be made as secure and comfortable as possible. They also decided to search for and collect provisions, of which they now stood in need.

"As I have been so successful in the hunting line, I'll look up some more food, if the Professor so orders," said George.

"I could not order you to do so," answered the Professor; "but you are adapted for that sort of work, and I therefore gladly suggest that you should make that your task."

Harry for the first time showed that he was annoyed. The Professor's keen eye noticed it.

"The spirit which tries to dig down into things and find out about them is a great gift. I am glad to see you possess it, George. But there is also another spirit possessed by other men, which takes the things that have been discovered and utilizes them. You, Harry, possess that trait."

"Which is the greater of the two?" inquired George.

"You cannot compare greatness in such a case."

"But who is the more valuable to the world?"

"One is just as important as the other, because one without the other would be useless. For instance, the discoverer of the electromagnet had no idea that the magnet would enable man to make a dynamo. It remained for the experimenter and the practiced worker to demonstrate that. In the progress of the world these two factors had to work side by side—one discovering a hidden fact, and the other using it in a practical way in the workshop, the field or the mine."

"Then I suppose I am the theorist," said George.

"Yes, and you, Harry, are the practical man in our enterprise. You know George is, generally, the one to ask the questions, and Harry is always ready to make the things needed for our wants. With such a combination no enterprise can fail."

George started on his mission with pride and confidence. Harry, for his part, certainly needed no other impetus to stimulate him. He was the builder, and he knew it and felt its influence.

But to be a builder—to make things out of the materials which were all about him, without a tool or implement of any kind, was indeed a task which might discourage the stoutest heart.

George's quest on this day led him up among the hills beyond their habitation and in the direction of the forest which lay beyond. Here he was rewarded by the sight of nut-bearing trees, and great was his delight when he recognized a species of nut like the walnut, which at this season of the

year was still green and undeveloped. What interested him most was a large globe-shaped nut, four inches in diameter, which he picked up and attempted to break. All his efforts were resisted, because he could use only one hand. Finally, he threw it away in disgust.

As he proceeded further up the hillside he was rewarded by the signs of berries, of which he gathered a goodly quantity.

On his return he saw many trees laden with the large, round nuts, and after selecting one as a sample, found a stone, which he carried to his companions.

"What luck?" exclaimed Harry; and George exhibited his samples of berries.

"I have something here which may be of some use, if Harry will break it open."

The Professor's eyes kindled. "And why did you bring that stone?"

"Because I thought it might be useful in breaking the nut."

"I suppose you are curious to know what it is?"

"By all means," cried both of the boys.

"It looks like the castanha, a species of Brazilian nut."

"I never saw a Brazil nut as large as this."

"Assuredly not; the thick shell is merely the outer coating of the nuts themselves. Here, Harry, see if you can break it."

Harry took the stone, and was about to crush the nut, when the Professor seized his hand and grasped the stone.

"Where did you find this?"

"On the hillside."

"Well, you are in luck to-day."

"What is it, Professor?"

"A grindstone."

"A grindstone!" exclaimed both of the boys, and Harry danced with delight.

"Now, let us proceed in an orderly manner; crack the nut, Harry."

After considerable labor, the thick, hard shell began to yield, and as it finally broke apart, the interior was found packed full of nuts nested together, revealing the form of the well-known Brazil nut. When first taken from the outer shell, before they are fully matured, as was the case with this sample, they are of a dark green color, but they soon turn to a chocolate brown.

"These are early nuts, but not yet ripe, but most of them mature or ripen after they are taken from the tree."

"We can use the shells for cups," said Harry, with eagerness. "It will be fun to shape them up."

"A very nice job it will be without tools," was George's comment.

With a smile, the Professor picked up the stone. "Harry can no doubt sharpen the clam shells with this. I need not say to you that observation is a trait which is not fostered by many people. To the true investigator the smallest thing may have the most tremendous possibilities. No doubt hundreds and thousands of people had noticed steam coming from the spouts of kettles before Watts saw it. What they saw was of no value

to them or to the world until Watts began to turn his ideas into practical use. So, you see, observation alone is of no value."

"But why does this stone, which is so much softer than iron, really cut away the iron?"

"There are substances held in the soft material of the stone which are much harder than iron or steel."

"What are the hard substances?"

"Some stones have fine particles of glass, or silicate. This sample is known as "Millstone grit," and it is usually the true bed of coal in the hills where it is found. It is often in layers with shale or slate and clay. If you have found such a seam we might form a company to work it."

The boys laughed at the idea, but the Professor seemed to be serious, and the boys awaited further information.

"You may well laugh at the statement, but our mine may be of immense importance to us in the future."

"But isn't it pretty hard to shape up the stones which have such hard things in them?"

"It isn't hard when one stone is so arranged as to cut another stone."

"And how is that done?"

"Two large stones are set to revolving in contact with each other, so that there is very much friction, one stone being made to turn a little faster than the other, and in this way they mutually wear each other away."

"Is that the way all stones are made?"

"No; most grindstones are now made arti-

ficially. Ruby, one of the precious stones, is found, in the form of sand, in the mountains of North Carolina and in many other places, and is used with a cement or other binder which hardens. As ruby is next in hardness to the diamond, it will grind or polish any of the metals."

"Do all the other precious stones make good grinders?"

"What you call the other precious stones are all of the same kind, but vary simply in color and in hardness. There are sapphires which are blue; the amethysts which are violet; and the yellow topaz. The common names used for these finely divided and sand-like forms of the gems are corundum and emery."

But Harry couldn't long remain idle after the idea of the grindstone had been fully absorbed.

The clams, of which they now had an abundance, were, many of them, large specimens, the shells being thick and heavy. The first thought that came to Harry was to fashion some of the shells into knife-like tools, and although this required an immense amount of effort, it served their purpose in cutting small pieces of wood. After he and George had made several trips to their mine, they were able to bring home several samples of large, gritty stone, and with these they succeeded in making several ax-shaped blades, to which, after some experimenting, wooden handles were fixed.

To do this they were compelled to unravel the skirt of one of the coats so as to get enough cord to tie the hatchets fast to the handles.

Their articles of food now included not only clams, but vegetables, of which George had found only a limited variety, and berries, but no other fruit was yet available.

In one of George's wanderings he gathered the courage to make a more extended trip. Carefully avoiding the forest, he was surprised to find a stream, about three miles from their home, to the south, which was fully a hundred feet in width. On approaching he descended the hill and when he had gained the lower level he found the approach marshy and covered by a peculiar bush, which had beautiful green leaves with saw-tooth edges, and which terminated in a long, sharp-pointed end. He attempted to break off one of the stems, which carried at its top several dozens of thickly clustered leaves, but was unable to do so, until he finally succeeded in severing it with his shell knife. He had scarcely secured his trophy when he was startled by the movement of some large object less than fifty feet away, which moved the brush from side to side and emitted an unfamiliar sound.

George was stupefied with fear. He was afraid to move and thus reveal himself, so he quietly sank down, while the unmistakable movement of the animal appeared nearer than before. A rustle at his side also startled him. It was a large greenish-brown snake. The sight so frightened him that he started back, and in doing so grasped the bush to prevent falling as the snake glided away. At that instant the movement of the animal ceased. Peering cautiously in

the direction of the threatened danger he was able to get a view of a portion of the beast, and almost involuntarily he shrieked. The cry so alarmed the animal that, with a bound, it turned and fled before he could discover its nature. The tall underbrush prevented his following its movements. In great agitation, his limbs almost paralyzed, he started for the slope, looking back in momentary expectation of pursuit. When he reached the summit, and had somewhat recovered from his fright, he started for home as fast as he could run.

After traveling a long distance, certainly far enough, as he thought, to come within sight of the home, he stopped. The hills were rugged, but everything appeared unfamiliar. He passed objects which he had not seen before, and then tried to get his bearings, wandering first in one direction, then in another. He retraced his steps, or tried to, and after what seemed hours to him, it flashed upon him that he was lost.

The animal which caused all the trouble was the first he had seen, and was evidence that they had dangers to contend with in that direction at least. The ocean could not be seen from that point, and in his perturbed state he was unable to decide the direction he should take or what course to follow. He had the instinct to know that the river must flow to the sea, but the direction of the river was as great a mystery as the location of the home. The sun offered no guidance, and hour after hour of wandering followed, until hunger began to warn him.

Meanwhile the Professor and Harry spent the time anxiously awaiting his return, and midday passed without any tidings. "You must search for him, Harry; he may be lost or injured. Let me warn you, before leaving: take bearings of the position of the sun and the direction the shadow falls. Be careful to note not only the formation of the land, but of objects which you meet; but turn about and examine them after you have passed them. You will find that they do not look the same from both viewpoints."

"Do you know the direction George took?"

"I am not certain, but it seems to me that he went toward the forest."

Without further words, Harry grasped one of the large clam hatchets and speedily gained the summit of the nearest hill, to the left of which was rolling and uneven ground, and to the right the forest. Carefully noting the sun, the forest and their home, he ran down the incline and began the ascent of the next incline. Beyond was a rugged line of hills with white and brown streaks, a plain enough object for him to note mentally. In the ravine was a small stream of water, which he crossed, and he then passed by the white and brown bank formation. The underbrush now increased in thickness and many unfamiliar bushes and shrubs arrested his attention.

The forest was now to his right and the sun was still at his right shoulder. Fully an hour passed by, and still no sign of George.

George, fully exhausted, lay down on a ridge, below which he could now see the floating stream.

His heart leaped with joy. He knew the little stream must flow to the sea, or to the stream which would go to the sea, and he bounded down the slope, first to quench his thirst and then to follow the stream to the sea.

As he was about to drink, he saw in the soft soil at the water's edge a footprint unlike his own. It was unmistakable. He looked at the prints again. This was a shock to him, but curiosity prompted him to follow the steps until he lost the traces, then he turned in the opposite direction and followed the course of the stream in its windings. While thus moving down the stream he heard a cry, the call of a human voice. He heard his own name, and with an exultant shout he answered.

"Where have you been?" was Harry's eager question.

"Where am I?" was George's only answer as Harry rushed up.

"You are not far from home."

"Oh, I would have made it," responded George, ashamed to admit he had been lost.

"But if you were not lost, why did you ask where you were? But where is your hatchet? I thought you took one with you."

"So I did." He had forgotten its loss, but he was eager to relate the encounter with the animal and the snake. It was there he lost the hatchet and the sample of shrub. But here, all around, he saw the same plants with the bunches of serrated leaves.

"Look here, Harry, this is the funny looking

weed I told you about at the time I saw the animal."

A sample was cut off, and as they started for home they again passed the brown and white cliff.

"I wonder what that can be?" said George.

"Mud, I suppose," was Harry's retort.

But this did not deter George. "Wait until I get some of it." And springing up the bank, with the aid of Harry's hatchet a good sample was procured.

In less than half an hour the boys reached home, to the great relief of the Professor.

"Yes, I suppose I was lost," was the final admission of George.

"And lost near home," said Harry.

George detailed his experiences in full, and after he had partaken of some food, the Professor took occasion to give him the advice which he had previously given Harry early in the day.

"You should know, boys, that the adventurer in an unknown land must, for his own protection, know his position at all times. It is so with the chemist, who must be able to follow back experimentally each advance he makes. A landmark by itself may look the same from any direction, but the surrounding objects make it appear variable from different standpoints. Amazing discoveries have been made by lost explorers in the sciences, as well as by adventurers on land and sea. Being lost is not, therefore, the worst of calamities."

"But I don't suppose I was really lost," said George. "I was confused, and——"

"No, I suppose not," said the Professor, with a

smile. "You were probably, like the Indian who, when asked if he was lost, replied, 'No, wigwam lost.' That idea is not a bad one, though coming from a savage. To the true adventurer or scientist the object is always the lost element. Man is only discovering himself."

"I wonder what that animal was," inquired Harry. "We must be ready to defend ourselves, and now that we have made a beginning with some tools, we ought to make some weapons."

"I leave that to your ingenuity, Harry."

"Then we can at least make some bows and arrows."

"I hope we can commence making them tomorrow."

"But what can we use for the strings of the bows? I am afraid our clothing won't hold out, even if they make a cord strong enough to stand the strain."

Apparently the Professor anticipated the question, as he picked up the sample of weed which George had brought.

"Why wouldn't this do for the strings?"

You may be sure that by this time the boys were not disposed to laugh at the seemingly absurd remark.

"I am glad that your disposition to learn things has induced you to bring this home."

"Is it really a valuable plant?"

"Yes; it is the ramie plant."

"What is it good for?"

"To make strings from. It is a fiber plant, probably the most wonderful of its kind in the

world. The stems resemble hemp in length and thickness, and in fineness it is the rival of flax. Jute is the only fiber which has a silken luster like the ramie."

"I know what flax is, but what is hemp?"

"Hemp is a native of Asia. It is an annual crop—that is, it must be sown each year, like wheat. It doesn't look unlike flax and is very tough and strong, being used in the manufacture of rope, such as the one we unfortunately lost."

"But isn't jute the same thing?"

"No; jute is a native of Bengal. It requires a very warm climate. It is so fine and glossy that it is used to mix with silk, but is not good for ropes. Most gunny bags are made from jute."

"Then we can make use of the ramie, if it can be put into shape?"

"Yes; it will be the most serviceable of all fibers, because it seems to be unaffected by moisture, so it will be useful for clothing, if we can find a way to weave it."

"And what is this, Professor? It is another one of our finds."

"Just common clay."

Harry laughed, and George's countenance changed. He had lugged some of the stuff Harry called "mud" a long distance to no purpose.

"Don't infer that we cannot make any use of it. Before we are through with Mr. "Mud" you will change your opinion as to his usefulness. Clay of this kind is a signpost that we ought to read. It is an indication of something beyond."

"What do you mean?"

"I mean that all clays have their characteristics which point to some other substances. It may indicate the presence of iron, or it may be in the form of a clay slate, and it may also indicate the vicinity of mica, which would indeed be a good thing as a substitute for window glass. It might come handy in many other ways that the future will tell about."

"Well, can't we use this for making brick?"

"Good idea," said George.

"That is worth considering, but the clay looks a little suspicious," was the Professor's remark, as he carefully examined the sample. "I am afraid this clay has calcium in it."

"What is calcium?"

"It is lime."

"Does that make it useless?"

"Well, yes, if there is much of it there, as, in burning, the lime fuses and forms gas bubbles, and so destroys the form of the brick and makes it crack. Did the bank show white streaks?"

"Yes; that's what made it look so peculiar. I wouldn't have noticed it otherwise."

"Then, as we can't make any test with acids, we may safely conclude that it is lime." This ended the discussion.

Night approached, and weary with the day's adventures the boys retired.

Early the next morning the usual daily conference was held, and Harry set about his task of making weapons. George volunteered to get

a supply of the ramie plant, and on returning cut off the tops, under the direction of the Professor, and he was then told to collect the stalks and put them into water.

"Now here is the first use of your clay. It is well suited as a lining for a little reservoir."

This necessitated another trip for the clay.

"What is the object of putting the stalks in water?"

"Because, when the stalks are thoroughly saturated with water, or moistened, the water is drawn off and the stems are allowed to rot."

"But doesn't that destroy the fiber part?"

"It would if we allowed it to remain too long. The woody structure of the stalk has more or less starch in it, and that first begins to disintegrate or fall apart."

"How long will this take?"

"That depends on the conditions. Warm water will hasten the process. But it will take some days to do the work."

Harry was disappointed.

"It is well worth the while. There will be plenty of work to do in the meantime. We have been so busy taking care of ourselves and trying to get something to eat that we have neglected learning some things that will contribute to our safety."

"That's the reason why I was so anxious to make the bows and arrows," said Harry.

"Quite true; but there are other things besides weapons that we must have and find out about in order to protect ourselves."

"What do you mean by that?"

"One thing is, I am not satisfied with the water which we are using. Then the fact that George lost himself, or lost us yesterday, was a warning that we must be able to find out where we are, or in what direction we are going, without depending on rocks or trees to guide us. You know sailors have no marks on the seas to guide them. Why, we don't even know the true north and south where we are."

"Then why not find out at once?"

"Because it will take at least twelve hours to do that."

"And why?"

"Because we haven't any instruments, and we must make them."

George and Harry had both seen the delicate and intricate devices used on shipboard to ascertain their location, and they could hardly believe it possible that the Professor would undertake to make such instruments.

"How shall we begin?"

"We must select a spot that is level and which will give us a good view of the rising and setting sun."

"Oh, yes, I know how to do it. A shadow at noon points to the north pole."

"No; to the south pole where we are," said George.

"But," answered the Professor, "how are you going to tell when it is noon, as we have no timepiece? We want to know the true north and south so we can determine from that the true time

at any period in the day or the night. Now, Harry, if you will prepare four stakes we will find our observation ground."

The boys were eager to prepare the implements, but he added, "We must wait until the sun goes down."

As it neared the time for the sun to set, the Professor asked whether either of them had a measuring line, but there was nothing of that character available.

"Without a measuring rule of some kind we can do nothing. You now see that such a simple thing as lack of a measure may defeat our enterprise. A measuring device of some kind is used in every field of human activity. If people did not have the quart or the pound, or the foot measure, the commerce of a nation would stand still. There would be barter and sale, but there would be constant confusion and turmoil. The sciences have advanced a thousand years in the last one hundred years, because in every department of knowledge some sort of yardstick has been devised."

"Can't we make our own measure?"

"Certainly; but why not make it reasonably accurate?"

"How long is a foot?"

"As long as a man's foot."

"How long is a man's foot?"

"In the different European countries, before the introduction of the metric system, the foot measure varied from nine to twenty-one inches."

"It is not accurate, then?"

"No; and for that reason the metric system was introduced."

"What is the metric system?"

"It is an absolute measure."

"By what is it measured?"

"By the circumference of the earth itself. That is something which does not change. One-quarter of the distance around the earth is cut up into 10,000,000 parts and each part is found to be a little over thirty-nine and one-third of our inches, or three and one-third inches longer than our yard."

"But I have an idea," said Harry. "I measure just five feet and three inches, or I did three months ago, so we can make a stick as long as I am and it will be pretty close."

"Of course, Harry, that makes you sixty-five inches high. Suppose we mark up the stick into sixty-five spaces, which will give us the length of an inch, and twelve of the inches will make a foot," observed George.

"That is a good suggestion," said the Professor. "Later we shall verify that by another standard, as I measure five feet eleven inches."

The sun was setting low when they reached the testing grounds.

"Now, Harry, drive in the first stake, and let George station himself there. I am now going to mark the direction in the sand, so you will know how to proceed."

The Professor then prepared a drawing so as to explain the method:

In the drawing (Fig. 6), A is the first stake driven by Harry.

"Now, Harry, go toward the sun and let us measure off, accurately, fifty feet, while George sights from his stake to the sun, and when it is

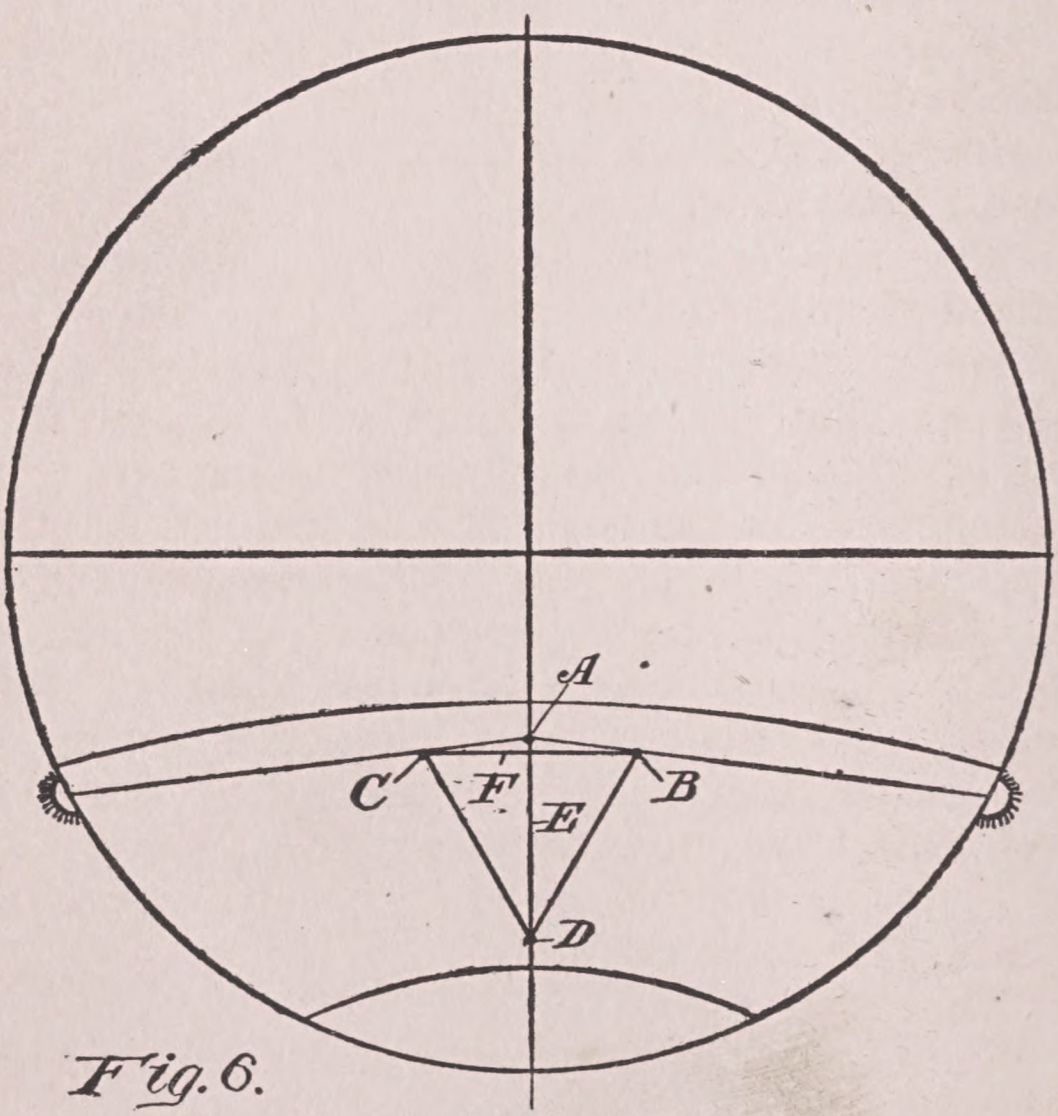


Fig. 6.

FINDING THE TRUE NORTH

exactly in line with the sun, drive in the stake there at the end of the fifty-foot measure."

Harry did so.

"We have now finished our task for the night. Early in the morning, before the sun is up, we must be here to drive another stake."

They then discontinued work for the night.

Early the following day, before the morning sun had a chance to appear, the boys were at hand and awaited the Professor.

"I see you are interested," was his first greeting.

"Yes, and we have the stake ready."

"What, only one stake? We must have two this morning."

George was about to run after it, but the Professor restrained him.

"The sun is just coming up. Measure out fifty feet toward the sun, and let me direct you where to place it—there, now drive it in. You will see that my drawing (Fig. 6) shows at C the location of this stake. Now look across from this stake C to the stake B, and you will see that the stake A is to one side of the line. That gives an angle which shows the position of the sun, or its arc of measurement from the equator. Now for the other stake. While George is getting it, you and I, Harry, will measure out one hundred feet southward from the two stakes, B and C, so as to get a meeting point of the two measurements, and mark the spot."

"Here's the stake."

When it had been driven in and marked D, the Professor asked what the three stakes, B, C, D, represented. George was quick to answer:

"A triangle."

"Yes; an equilateral triangle, with its apex to the north."

"No, no; to the south," was George's quick correction.

"Very true. But now, how can we tell where the true north and south are by the triangle?" was the Professor's inquiry.

"I see the object of the four stakes now. As the first stake is midway between stakes B and C, a line, like E, from D to A, will be the true north and south."

"Yes; and a line, F, from B to C, is the base or meridian line, or the true east and west."

CHAPTER V

THE VENOMOUS SNAKES

The entire day was spent by the boys in cutting poles and conveying them to their temporary quarters. By a great deal of exertion they succeeded in building an additional room and in tamping down a good, hard clay floor. Their efforts were then directed toward making the roof impervious to water, in anticipation of heavy rains.

They had been fortunate in having mild weather, and experienced only a few slight showers during their stay in the improvised house; and while they knew that their present home must sooner or later be supplanted by something better, the Professor urged them to get it into good condition during the time they were recuperating, rather than to remain idle.

He, no less than the boys, began to feel a keen interest in their surroundings, and as his health had now improved so wonderfully that he was able to take long walks each day, we may be sure his fertile mind was active during his ramblings.

One evening, while engaged in the usual discussions, George said:

"Professor, you once said that any floating object, when it comes near land, will always go to the shore. Do you mean that the land attracts it?"

"No; the land does not attract an object."

"But beaches everywhere are covered with things that are carried there by the sea."

"I think I can explain that," said Harry. "The waves carry them to land."

"Do you then think that the waves move along?"

"Yes; I have seen them move."

"You are mistaken; waves do not move in such a manner as to carry an object along on the surface of the water."

"But they seem to move in that way."

"Waves are impulses which move up and down only. A cork thrown on water will simply bob up and down, as the boys say, unless driven along by the wind."

"Then it is the wind which carries them ashore?"

"A floating object on the lee side of a shore, or in the sea near a shore with the wind blowing from the land, will move it toward the shore, directly against the wind. How do you account for that?"

"I cannot account for it."

"Then I will tell you. The land slopes down into the sea, making an inclined shelf, as it were. Waves are mere surface agitations, and the nearer these waves are to the extreme shore line, the more boisterous they become. The waves have a tendency to maintain their up-and-down motion, but are finally arrested by the beach and thrown back, so that, as their oscillations continue unceasingly, they must go back, and in doing so they crawl down the sloping beach, the water return-

ing under the oncoming waves, as it were, producing a kind of undertow.

"This undertow sets up a motion of the surface water toward the land, and the undertow goes back to sea along the shelving bottom. When the tide is ebbing this undertow is very dangerous."

"Oh, yes; I have heard of people being carried out to sea by the undertow, and I now understand what it is."

"So you may fully get this in your mind, I show you a sketch (Fig. 7), in which A is the sloping beach line and B the waving surface of the sea.

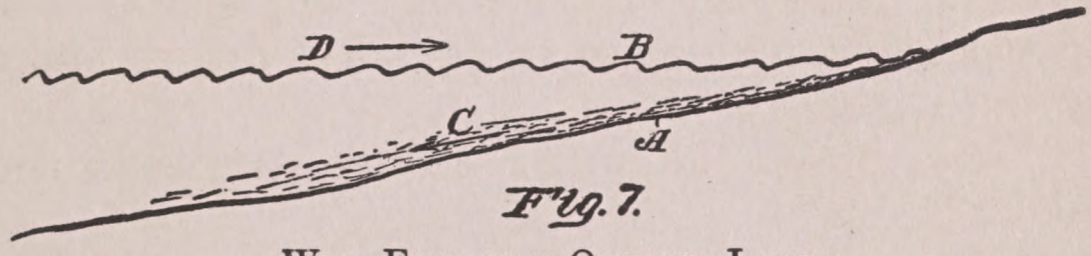


Fig. 7.

WHY FLOATING OBJECTS LAND

The dart C shows how the water is running down the bed of the ocean, and returning, as the dart D indicates, toward land, and thereby carrying objects with it."

"But is that so when the tide goes out as well as when it is coming in?"

"Yes, and for this reason: A column of sea water, one inch square, weighs one pound for every twenty-six inches in height, so water resting on the bottom, where it is deep, exerts a great pressure downwardly, and produces a powerful influence at the bottom to push the water down the incline and out to sea. When the tide moves

from the land the bottom layer of water is really displaced, or pulled away first."

"And now, Professor, while we are on the subject, you told us, some days ago, while we were talking about the water, that you were suspicious about the kind we were using. Do you think it is bad water?"

"No, because the source seems to be all right. I do not think it is unhealthful, except that it is a hard water."

"I have often heard that expression used. What does 'hard' water mean?"

"It is water that contains calcium, the same substance we found in your samples of clay."

"I know; you mean lime."

"If hard water is taken in excess it affects the arteries by coating them with lime, so that the nutriment carried by the blood from the heart cannot be absorbed through this lime coating, and the result is disease."

"I wish we could build our house near a good spring—that is, if we cannot find good water or provide a way to treat it."

"For our present purposes, simple boiling of the water is sufficient. If it contains a large percentage of lime, the water will appear milky just before it begins to boil."

"I have noticed that with our water here, particularly since we finished the last slate boiler which we made," said George.

"Hard water does not saponify—that is, the lime prevents the water from turning into soap."

"I wish we had some soap."

"Then we must find means to make it. Let that be one of our first tasks."

"What do we need, Professor?"

"Fat and lye."

"That is where our bows and arrows will come in handily," said Harry.

When the boys awoke the next morning they were informed by the Professor that the ramie had been sufficiently decomposed so they might recover the fiber from it. The stalks were taken out carefully and laid on one of the slate slabs and dried in the sun, after which it was beaten. The boys had the pleasure of seeing the woody part of the stalks break up, so that it could be blown away.

"This is called 'breaking' it; and now, as we have freed it from the wood, it must be combed. It likes to be caressed, and it grows glossy. See how it shines as you stroke it?"

"What beautiful threads! Is it now ready to twist?"

"Yes; as soon as you like."

The Professor then showed how, by twisting and adding a few threads at each turn, a long thread was finally made, which was tightly wound on a round spool of wood.

"Is it necessary to wind it this way?"

"The principal object in winding it is to set the twists which we have made."

"Oh, yes; so it will not unwind when we need to use it."

The boys had previously fashioned a number of bows from the dried limbs of such trees as they

were able to find, and for arrows they discovered a reed, exceedingly tough, for which they had ground a quantity of shell tips.

They were instructed how to fill the hollow end of the reed, behind the shell tip, with clay, so as to give it added weight, and the forward end of the arrow would thus be heavier than the tail.

They were surprised and delighted at the wonderful strength of the ramie cord. Each day they practiced with the weapons, using a target of leaves, which they had made up loosely to protect and save the arrows.

Thus, by constant practice, day after day, they became skillful archers, until finally they could hit a target at a distance of one hundred feet with fair accuracy.

"If our militia is now fully equipped, we might form an expedition of conquest," said the Professor one evening.

This was a welcome suggestion. "Can't we start in the morning?" asked Harry.

"If we can get ready. But we need provisions for several days at least, and our house must be closed up; when that is done, if you have sufficient ammunition, in the shape of arrows, we may start."

George's arm had now completely healed, and the Professor was enjoying better health, as he expressed it, than he had experienced for years.

During the day Harry devoted much of the time to making arrows and assembling them into convenient packages. George gathered a quantity of vegetables, as well as nuts, the latter of

which had the kernels removed so as to save weight, as they expected to be able to gather fruit along their route.

In all these preparations the ramie cords which they had manufactured, and of which they now had quite a supply, were of the greatest value to them. Without fabric of any kind by which they could form carrying receptacles, a goodly supply of cord was an admirable substitute.

The articles were made up into two bundles, but the Professor insisted upon carrying his share. Thus prepared they selected a day which opened clear and calm, and the little expedition started for the interior in search of adventure and with a view of exploring their adopted country.

It was decided to follow the course of the sun westward, which would bring them into what appeared to be the higher portion of the island. They traveled slowly, examining every ravine and hillside, making detours, so as to be able to investigate the character of the shrubs and trees which grew on every side.

Before noon they saw a great variety of trees, but the most noticeable of these were what appeared to be palms, with tall, thick trunks and bunched, fern-like tops. These attracted the boys' attention for some time before inquiring about them.

It had been the Professor's custom not to bring out any features of information directly until the boys called for explanations. He believed such a

course to be of greater advantage, as it would cultivate a spirit of research.

"What kind of trees are those, Professor?" asked George, who had kept silent for some time.

"That is the sago-palm."

Both boys then eagerly began the questionings.

"When does the sago seed ripen?"

"It never ripens; because what you have seen is not seed."

"But what makes it look like little grains?"

"The trunk of the tree is grated—that is, the inner or pith portion and the starchy or white matter is washed from it. It is then dried and ground up into a flour."

"Can't we do that?"

"Certainly; with the proper apparatus we can do anything."

"How easy it is to cut," said George, trying a few hacks into the tree.

"The flour thus made is formed into a paste and pressed through coarse sieves, so as to make the pearly grains which you mistook for seed," resumed the Professor.

"I have seen so many of these plants everywhere," said George, pointing to a bush, about two feet high, which had at the top of each stem a hand with six leaves like radiating fingers.

"Dig it up, and let us see what it is like. Dig deeply, so you will get all of the roots."

The boys carefully removed the earth and were surprised to find several large bulbous roots.

"Sweet potatoes!" exclaimed Harry.

"No; they are the Cassave, a good substitute

for potatoes, and it is now being introduced extensively throughout the United States. It is the finest food in the world for stock."

"I never heard of it before."

"I think you have eaten it frequently."

"What does it taste like?"

"Exactly like tapioca."

"And is tapioca made from the Cassave?"

"Yes; the root is dried, while moist, on hot plates. The heat causes the starch to expand so the whole root breaks up. When this is put into water and boiled, it swells and form a jelly, which is the tapioca as we know it. When the root is dried and ground it makes an excellent flour or meal."

"What is that animal there?" asked Harry, breathlessly, pointing down the incline.

Surely enough, there was a small animal calmly surveying the party, and Harry, with the instincts of a hunter, cautiously stole forward on hands and knees in the direction of the animal, shielding himself behind a clump of bushes.

Before reaching the bush he sprang up with a cry of pain and, dropping the bow, held up his hand. The Professor sprang forward, just as a snake glided away.

"Catch the snake, George. We must see whether it is venomous or not." Despite George's efforts, it escaped him.

Two well-defined punctures appeared in Harry's wrist, from which a little blood flowed, and the Professor, with an ominous shake of the head, directed George to bring some cord at once. After

binding some leaves around the arm, between the wound and the elbow, he wrapped cord around the leaves so as to make a tight band. The next step was to cut a cross through the skin across the punctures.

"Why do you put the band around the arm in that way?" asked George.

"To prevent the poisoned blood from being carried back to the heart."

"But will that pressure prevent the blood on the inside of the arm from flowing back?"

"The veins which carry the blood back to the heart are near the surface of the body; but the arteries, which bring the blood from the heart, lie further within, and are, therefore, protected in a great measure. And now keep in motion, Harry, while I search for some medicine," continued the Professor, as he hurriedly left them.

In a brief space of time he returned, holding in his hand a small plant, with roots attached, which looked like small parsnips with scales on them. He removed the scales from a portion of one of them, crushed the pulp, and applied it to the wound.

"We might keep some of these bulbs for breakfast," he remarked.

"What are they?"

"Arrowroot. Don't you see that the shape of each leaf is just like an arrow is, or ought to be? But there is another reason for calling it 'arrowroot.' The raw root is used by the Indians for extracting the venom of poisoned arrows."

"What a splendid name!" observed Harry.

Within an hour the tightened band was removed, and the greenish color on the different applications of the arrowroot was evidence of the fact that the poison had not entered Harry's system.

"But my animal got away," said Harry, grievously. "Wasn't that too bad?"

"And so did the snake," was George's rejoinder.

"Yes; if we could have seen the snake we might have been able to judge whether it was poisonous or not without making such a test as we had," added the Professor.

"I know the rattlesnake is poisonous," said George, "and I have often seen them, and know them by the rattle on the tail."

"But," remarked Harry, "there are many poisonous snakes which have no rattles. How can you tell them from those which are not poisonous?"

"There is one characteristic belonging to all of the rattlesnake species which are poisonous. All have a pit in the head between the nostrils and the eye. Non-poisonous snakes are not so marked, excepting in the adder species. There are only two poisonous species—that is, the rattlesnake and the adder."

"Was that the reason you wanted me to catch the snake?"

"Yes; I didn't think it was a rattlesnake, as they never strike without first giving a warning rattle. The rattlesnake is very polite. There are few adders in the western hemisphere. Their native place is Europe. Vipers and asps belong to that

class, and not to the rattlesnake family. The viper's fangs are not grooved like those of the rattlesnake."

By this time they had reached very broken and somewhat elevated hills in which they found innumerable sharply defined and steep peaks. They passed along at the bottom of one of the intervening ravines and at the Professor's suggestion examined the peculiar green outcropping.

"This looks like native copper, and it might be well to note this spot, as we may soon have use for it," remarked the Professor as he deposited his package and proceeded to make a more careful investigation.

It was only too true. The finding of a ledge of free copper would enable them to recover it for use without expensive ovens or retorts.

The forest now appeared to cross their path to the west, and it extended far to the north, but after some deliberation they determined to penetrate it.

Numerous springs had been found along their route and they had secured an abundance of fruit, wild plums, and also a species of wild pear (the latter rather bitter), so there was no danger of a famine.

"As we progress through the forest, our first care must be to keep our reckoning. If we cannot see the sun, we must direct and maintain our course by observation. By doing so we can make a straight path through the forest."

"If you show us, we will go through the forest

by making observations, so as to become accustomed to it when the sun doesn't shine."

"Did it ever occur to you what the expression 'aim in life' means?"

"Well, I suppose it means something to strive or work for," answered Harry.

"I think it means to accomplish something on which you have set your mind," responded George.

"But what does 'aim' mean? Does it merely mean purpose or object? What is its meaning in archery or gunnery?"

"To point or to direct the weapon to an object."

"Well answered; but how do you aim? Simply by pointing the weapon?"

"No; by the sights."

"Then why not prepare sights as we pass through the forest. The sight may be a large or peculiarly formed or colored tree, two of such being always in line, as we move forwardly. One tree, in that case, must always be selected, while we have two closer trees in line. Then what next?" asked the Professor.

There was silence.

"We must blaze the trees we pass."

"How are the trees blazed?"

"The bark is chopped off the trees along the path on two sides, so that you may see the blazed tree in either direction. These marks are like memory in man. They tell you events. Memory is man's most important faculty; and so are these blazed trees the most vital requirements in building a path through an unknown forest."

Before they had time to select the distant trees

for observation, the Professor called attention to a moving object in the bush, traveling along very deliberately.

"Now, boys, you may have an opportunity practically to test your weapons. I cannot see just what kind of an animal, but it is evidently not much alarmed by our presence."

"I think it will be a good scheme," said George, "for us to creep upon it as cautiously as possible, so we can both take a shot."

"Before doing so, look around for a place of retreat. If it should be a vicious animal, you can both rush to the spot and thus mutually protect each other."

"This fallen tree will be better than nothing."

"Very well, then," said the Professor. "I will remain here."

The boys moved forward carefully, for they were now at the margin of the wood, and after quite a time had elapsed, Harry crept back cautiously, and said: "It is a cow, Professor—a real cow."

He lost little time in following Harry, and when they reached the observation point where George lay, he made a careful examination of the animal.

"It is a yak," he exclaimed. "You are not far wide of the mark in calling it a cow. It is different from the Asiatic yak in two particulars. It is much smaller than the eastern species and doesn't have the long woolly hair which, in the yak of Thibet, hangs from its body nearly to the ground. It is of the bovine species, like the common cow, and is easily domesticated."

"What shall we do, Professor?"

"You can't kill the animal with your arrows, and it would be of no value to us to injure it. As it is a female, we may be able to find its calf. I suggest that we show ourselves and follow its movements. If it has companions it will certainly lead us to them."

Acting on the word, they exhibited themselves, and the yak, after noticing them, did not appear to be unduly alarmed. It had a pair of horns, not unlike the Texas steer, and while the Professor assured them it would not be likely to make an attack, except in self-defense, they were, nevertheless, very cautious. The yak continued feeding, until they came within less than a hundred feet, when it leisurely turned about, and made a circuit around them, not even deigning to look back.

They followed with eagerness, and before proceeding far saw at least a dozen more of the animals feeding, and among them a number of calves, which sight delighted them beyond description.

"This is one of our discoveries we can take advantage of and turn to good account on our return," remarked the Professor. "For the present we must proceed upon the journey mapped out."

Again resuming their march, note was taken of the trees which would serve as initial guides for the trip through the forest.

Night was now setting in and a search began for a suitable camping place. The collapsible water flask was still filled, as it was always held in reserve. Harry and George acted as scouts in different directions, being instructed by the Profes-

sor to keep the large oak trees in sight. Within ten minutes Harry rushed back, carrying what he called a groundhog, that he had shot. He was fairly dancing with excitement and shouted for George, who had also heard the shot and soon appeared.

"And now for a feast," said he.

The woodchuck, by which name it is generally known, is an animal found in all countries from North America to Australia. It belongs to the squirrel family, is from twelve to fifteen inches long, and its flesh is very palatable.

"As we need the pelt of the animal, I will skin it, if you will select our camp site," said the Professor.

"I have found an excellent place," was George's welcome remark, as he had been guided by their former experience in selecting a fallen tree. He knew that such a place would, in case of attack, offer some security.

The woodchuck proved a most grateful change from their hitherto scanty bill of fare.

"I am so hungry for meat I can hardly wait," said Harry.

"It doesn't seem," said the Professor, "that meat is an absolute necessity for man. In my own case, I have recovered, gained strength, and am now more vigorous than I have been for years, without having eaten any meat for many weeks. It seems to show that man, of all animals, is adapted to maintain life on either fruit, vegetables, meat or fish, and some tribes live on earth, or certain clays."

CHAPTER VI

THE COMBAT BETWEEN THE BEARS

Early the next morning they were astir and eagerly prepared for the experience of penetrating the forest. During the first two hours they made slow progress, as the forest was dense, and their course was crossed by two streams, which were forded after some delay. They finally reached a clearing where there was considerable underbrush, and as they emerged from the thick wood were startled by the angry howlings and snarlings of wild beasts.

There was a hurried consultation, Near by was what appeared to be a mound, surrounded by bushes, which they reached. George sprang to the top, peering in the direction of the sounds. They deposited the provisions on the mound, and cautiously crept forward with the weapons in hand, the Professor also being equipped with a hatchet and a bow. They had not proceeded very far before they saw the outlines of two black animals engaged in a fierce combat.

"What is it, Professor?"

"Bears," he answered. "They are fighting over the spoils. If I am not mistaken, they will furnish us the treat of our lives."

They were now rolling over each other, biting, clawing, and emitting the peculiar screeching grunt so characteristic of the bear when angry.

The smaller of the two was now by far the most active. But the strange feature of the scene was the appearance of the bears. They were covered with leaves and twigs, so that while, at first, they appeared black, they were now completely changed. The Professor laughed, and the boys joined in.

"Shall we take a hand?" asked Harry, now wild with excitement.

"No; that is a war to the death. It is one of the characteristics of those animals, never to let up until one or the other is vanquished."

"What do you suppose they are fighting for?"

"Honey, I imagine. I shall be very much surprised if we do not find a hive of wild honey somewhere near at hand."

"See, he has him!" The small bear by a dextrous leap had seized the large bear by the back of the neck, where he hung with grim tenacity. The weakened condition of the large animal now told against him, and every struggle served to make him only weaker. Finally, he became quiet, his legs stretched out stiff, and then he became limp. George could restrain himself no longer, and he fitted an arrow to his bow.

The Professor stopped him. "The bear has earned his life. One of them is enough at a time."

Instinct told the small bear what the inertness of his opponent meant, and he relaxed his hold.

"Now, boys, when I give the word, let us all set up a shriek and rush forward. Our friend,

'little bear,' will then get the surprise of his life. Now, ready! Shriek!"

Just imagine two healthy boys, with their lusty voices, under these conditions! Was the bear surprised? He didn't wait long enough to let anybody find out. He left, apparently satisfied with the honey he carried away on his fur.

With shout and laughter the boys made their way to the fallen bear; and here a sight met their gaze. The bear was covered with honey.

These animals are inordinately fond of sweets, and the Professor knew that such fights are not uncommon among them. Less than fifty feet away was lying the partially decayed trunk of a tree which had been broken off the main trunk about ten feet from the ground, and in toppling over it had split for a portion of its length, exposing a hollow filled with honey.

Here, indeed, was a gift of good things: Bearskin, bear's meat and honey!

"I can see where we spend the rest of this day," remarked Harry.

"And what shall we do with all the honey?" asked George.

"And with the bear?" inquired Harry.

"This incident gives a new turn to affairs," said the Professor. "If we go forward we must sacrifice the honey, and the bear as well. Considering the distance we have gone, since leaving our camp, I judge we can, unless too heavily laden, return in a day, and for that reason I believe it best to take the bear pelt and as much of the steak and honey as we can conveniently carry, and return,

where the meat can be cured and the honey disposed of for our future use."

The bear was skinned—a long and difficult task, with the awkward cutting tools they possessed.

"I am wondering how we shall be able to carry the honey," was Harry's query.

"That can be easily arranged," replied the Professor. "We shall use the skin for that, and also make it a receptacle for the meat."

"What! put the meat in the honey?"

"Certainly; why not?"

The boys laughed at the idea.

"We must preserve the meat in this climate, and honey is the best preservative known. It is certainly the best we have at hand."

"Why does it preserve the meat?"

"Because it acts as a seal, and also prevents germs from attacking the flesh. The present way of treating it is not the best, because it would be better to wash the meat before coating it with the honey. However, honey is a sterilizing agent in itself, and I do not think we shall have any trouble in keeping it long enough for our purposes."

"But doesn't the meat taint the honey?"

"Not at all. Our honey will be just as good."

All of them worked with a will, but even so, it was dusk before everything was prepared. You may be sure all were tired when they retired that night.

The next morning, with a beautiful sunrise, they started back on their journey. The bearskin bag was secured to a pole and carried on the shoulders of the boys, and they were thus able to trans-

port a goodly load; while the Professor took upon himself the two bundles of provisions and the other little necessaries which had been brought with them.

There was no lagging now. All was enthusiasm. But traveling under a load, hour after hour, is not an easy task, and it was late that day when, after repeated rests, they emerged from the forest.

By the time they reached home the sun had set. Too tired for words, they slept soundly until late next morning, and when they woke George's first exclamation was: "Too bad we have to use all that good honey on the meat!"

"Then suppose we cure it with salt?" said the Professor.

"I haven't seen any salt around here, except salt water, and you advised us against using that. Sea water can't be very dangerous, is it?"

"Not by any means; only it is not good for drinking purposes, and it really ruins the taste of food. Besides, we have not found any need for it with our vegetables."

"Well, they would taste better, any how."

"Yes; they would probably taste better; but that is an acquired habit, like many other things. All vegetables contain in themselves sufficient salt for our needs, and it is in that form which is best assimilated in the human system."

"I should think," said Harry, "if people, generally, use salt, and crave it, that would be a good reason why it was intended man should use it."

"It does seem so; but you must bear in mind

that we use vegetables in an unnatural way, by removing skins or outer coatings, which contain the very form of salt most desirable for digesting purposes."

"What, do the outer coverings really contain salt?"

"Yes; and potash, or potash salts. All our grain is bolted, to take out the bran, which contains essential foods, of which salt is one of the principal elements."

"What is there in sea water which makes it so bad for seasoning purposes?"

"There are about thirty solid elements in it, and all of them combined form about three and a half per cent. of the bulk of water. Among those elements are Glauber and Epsom salts."

"Well, it is no wonder it doesn't have a good taste."

"Can the common salt be taken out of sea water?"

"Yes; but it is difficult to do it without the apparatus. The chief source of salt supply is from the salt rock, found in many places throughout the world."

After thoroughly recuperating from their journey, the Professor proposed a jaunt to the hills where they found the copper deposit. All intent the boys consented, and in a short time were ready for the start, and took their weapons, as usual.

They also detached a portion of the bearskin to be used as a carrying receptacle, and with this they gathered a quantity of the free copper, making a sufficient load for one trip. During this time

the Professor was constantly on the alert for evidences of pure clay deposits, and was rewarded by discovering a bank which appeared to contain the right kind.

He announced the discovery and marked the spot, after taking along as much as could be carried.

"George's inquisitive nature could not hold him back any longer: "What is all the clay for?" he asked.

"We are going to work our mine, and shall need vessels of various kinds. We also want to put copper to work for us, doing many useful things."

George could understand the use of the vessels, but he could not conceive how copper could be put to work. While thus reflecting, the boys saw him quickly drop his load and spring up the hillside, where he detached a specimen of black, or dark-brown earth, which he held up triumphantly.

"What is it?" they cried.

"Blende! What a wonderful island this is!"

"We never heard of it before. What is blende?"

"It is the ore in which zinc is found."

"But zinc is white, isn't it, Professor?"

"Not in its original form. This color is due to iron or sulphur. It is never found in a free state, as is the case with copper, iron, or gold."

"We may have little use for it," said Harry.

"On the other hand, it is one of the most useful of metals."

The subject of a new home, one better adapted to their needs, and close to a safer source of water supply, had long been an object of speculation on

the part of the Professor. Their trip through the forest convinced him that they were within range of a running stream which would afford power. At the same time they would be nearer the ocean, and, as the rainy season was approaching, it was imperative that immediate steps be taken to this end. His views were fully agreed to by the boys.

He was also curious to investigate the slate beds which George had discovered. Early the next morning, therefore, after collecting ample provisions, they marched over the hills to the slate cliffs. When the Professor began prospecting the boys made a tour beyond, on their own account.

"Suppose we go in the direction of the sea. We have not yet explored the cliffs," remarked Harry.

They turned to the right, going diagonally across one hill after the next, until they were less than a half mile from the cliff rocks.

As they reached the top of one of these hills they saw, to their delight, a small stream flowing to the ocean, and distinctly heard the sound of falling water. Making a detour, so as to reach the stream at a bend, they were gratified to find a beautiful little cascade, where the water flowed down a rocky raceway.

"This must be the first stream we crossed this side of the forest," said Harry.

"And what an ideal spot for our house," said George. "We must let the Professor know about this at once. So with eagerness, born of their zeal, the Professor was soon found, digging into the hillside, his clothing soiled and his hands black with earth.

"We have found it, Professor."

"So have I," he replied.

"Coal!" said both in a breath.

"Yes; and a very good variety, if I am not mistaken. Now, let me see what you have found?"

"We didn't bring it with us; but it is a real waterfall."

The Professor did not wait long after this announcement, but followed them with alacrity.

"This solves one of our great problems. What an excellent place for our house among the rock close to the falls, and we can locate our workshop just a short distance away."

Below the falls was a beautiful slope of green, extending to the edge of the stream, the upper side of the field being bounded by a semi-circular wall of rock.

As they were leaving the falls, the Professor stopped and pulled up a plant. "What have we here?" he exclaimed, as he turned to the boys and exhibited the stem which carried a number of pinkish flowers.

The boys followed him as he walked toward the stream, and crushed up the flowers and stem as he walked. When he reached the water he began to wash his hands, rubbing the plant while doing so.

"Soap!" cried Harry. "Just what we have been wanting."

"And good, soft water, too," answered the Professor, as he swung his arms to free his hands of the water.

"I see, it saponifies," remarked George. He had not forgotten the lesson.

As the sun was getting low, they started for home, determined to make preparations for mov-

Fig. 8.

THE SOAP PLANT

ing next morning. As they rounded the last hill, what was their consternation to observe a herd of George's "cows" leisurely wandering past the shack, and moving southwardly.

While the sight was an exhilarating one, they

knew it would be hopeless to attempt to capture one of the herd, so they contented themselves in counting them and noticing their characteristics.

"We must get one of those fellows some day," said the Professor. "Milk will come in very acceptably."

George was the first to reach the shack, but he didn't make an attempt to open it. Instead he drew back and held up his hand.

"We have captured one, sure enough," he shouted out. "How do you suppose he could have gotten in?"

"I now recall that I forgot to lower the trap," said Harry.

It was, fortunately, true. The herd, in wandering about, had approached the shack, and one of them, as it passed in, had dislodged the fastening of the door, which was made of boughs bound together, so that it fell down and trapped the animal.

"Well, boys, we have a job before us, if we want to keep the beast."

"Certainly, let us keep it," said the boys together.

"See here; the animal has company."

They peered through one of the openings, and discovered a calf. The animal was a female, and its young was probably a month old. There was now no further talk of liberating the cow.

"These animals are easily tamed, and are not at all vicious," remarked the Professor, as he viewed the captives, and nodded his head approvingly at the decision to keep them. It was considerably frightened and timid, of course.

It will be remembered that during the second week, after selecting the present site, they built an addition, which was used for their provisions, so the cow was quartered in their living room, and thus had the benefit of the beds of leaves they had made. Under the circumstances they concluded to allow the cow to remain there, and proceeded to fit up the storeroom with sleeping quarters, temporarily, after securing a quantity of leaves for bedding, thus making themselves comfortable for the night.

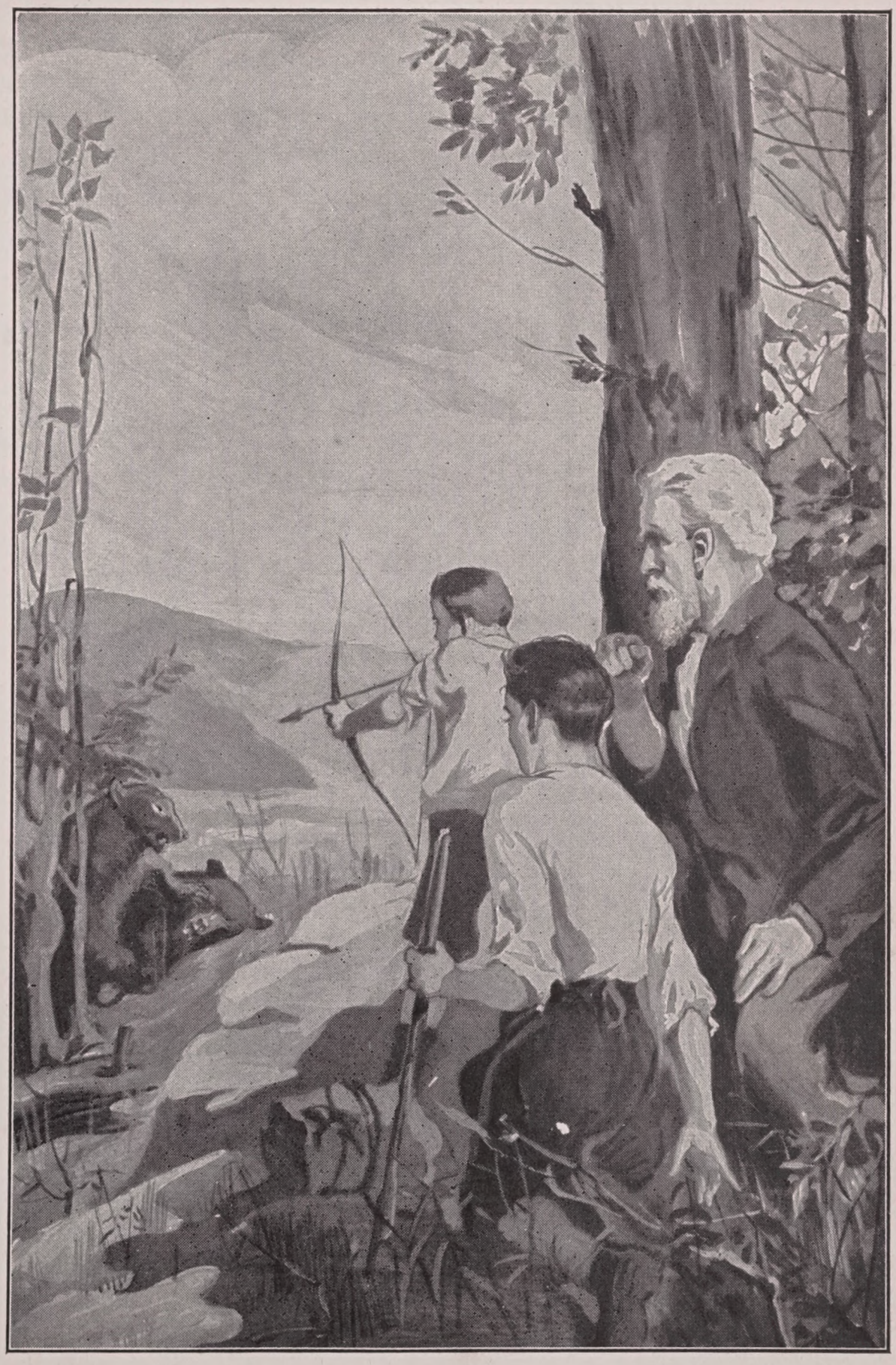
"You see, boys, the more we have, the greater will be the responsibilities. That is one lesson of life."

"Yes," said Harry; "but we can have milk, which we didn't have before."

Now began their busy days. To care for the cow and calf was indeed a problem. They had to provide water, and the spring on which they depended was some distance away. Food was not so difficult, but even this was not the easiest thing, as they still had no other cutting tools than the shell knives.

But they were undaunted. It had been their custom always to keep on hand a good supply of ramie stalks, which were soaked in water and then spread out for the decomposing process, so that they were gradually accumulating a supply of fiber. Usually the boys would hunt together, and only occasionally were they able to bag any game of importance.

One day, however, they had an exciting, if not dangerous, experience. While in the hills, seated



"George could restrain himself no longer, and he fitted an arrow to his bow"

[See page 92]

on the ground eating their luncheon, they were startled by the grunt of an animal near at hand. Above them, less than twenty feet away, was an object which looked like a half-grown hog. When it saw them it was, evidently, as much startled as they, but, nevertheless, it did not retreat.

Harry fitted an arrow into the bow, and hurriedly took a shot, the arrow finding a mark in the animal's neck, between the shoulders. With a squeal, not unlike that of a hog, it bounded forward, striking the ground directly in front of Harry, and with another spring struck him fairly on the left shoulder, so that he rolled over with the animal.

George, in the meantime, had an opportunity to grasp the heavy shell hatchet, just as the hog turned toward him. Without hesitating, he swung the hatchet, as the forward part of the animal's body came in reach, and succeeded, almost, in severing the animal's front legs at the first blow.

Harry, fortunately, was not hurt, and in an instant had recovered himself. He at once sprang toward his own hatchet, which was lying several yards away. Before he could deliver a blow the animal dropped over on its side, at which point George brought the hatchet down on its skull, finishing the combat.

When Harry's arrow reached the animal it struck at a point directly forward of the shoulder blades, and as its head was poised and Harry was below, the arrow pointed directly toward the location of the heart.

The force of the arrow was not sufficient to pene-

trate to the heart, but when the hog leaped forward and landed on the ground, the projecting shaft of the arrow struck the earth, and was driven far enough to reach the heart, thus finishing the work that the bow failed to carry out.

It was many minutes before they recovered from the excitement caused by the fight. They little realized how very creditable a victory they had won, or the danger they had encountered, in presuming to capture so formidable a beast with their puny weapons.

The animal weighed a hundred pounds or more, but they concluded, nevertheless, to carry it home, which they did by mounting it upon a pole and carrying it litter-fashion.

The Professor viewed the capture with a great deal of satisfaction. "It is the aardvark, or wild hog, and it is fortunate that you were unaware of its vicious character when attacked. See what a pointed nose and powerful tusks it has."

"Well," said George, "we can have pork now in addition to our other luxuries."

"Yes; and real soap," responded the Professor, as he viewed his still blackened and discolored hands.

The boys were directed to drive a circle of stakes close together, so as to make an enclosure one foot in diameter, and about two feet high.

The stakes were held together by a bow at the top. Within this enclosure the bottom was covered with clay, hard packed, and dished up around the sides for about six inches from the bottom. A

hole was then formed from the middle of this clay disk downwardly, so that it led out at one side.

"Now that is as good as a barrel for our purposes," said the Professor. "If you will get some

Fig. 9.

Ash Barrel

dried grass and spread over the bottom we shall be ready for the ashes."

A quantity of wood ashes was now poured on the straw and wetted down, as each layer was

added, and straw laid in along the sides against the stakes to prevent the ash from drifting out. In this way the barrel was filled, as shown in Fig. 10.

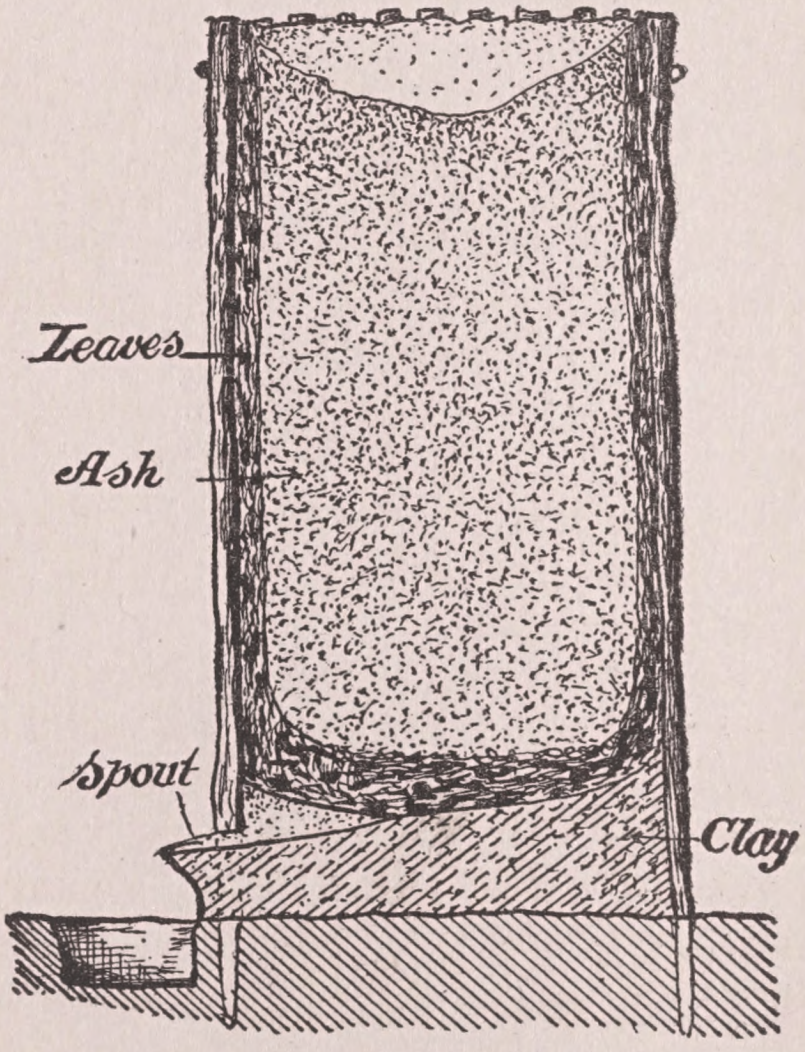


Fig. 10.

LEACHING LYE

The only utensils they had were slate receptacles, which had been cut and rounded, or hollowed out, by means of the grindstone, so they had to use all of their vessels for the purpose of supplying water and catching the lye. Water was slowly poured into a little hollow in the top of the

ash, and was permitted thoroughly to saturate the ash, and then, when the entire mass of ash had once become completely soaked, a wine-colored liquid, called *lye,* began to drip from the hole at the clay bottom.

When their slate receptacles were filled, the largest of them were put over the fire and the lye allowed to boil. To this was added some of the fat from the wild hog, and as rapidly as the liquid evaporated down, a fresh quantity was added, until a sufficient amount of fat and lye were united to form a saponifying mass. It was then stood to one side and allowed to cool.

The next morning they found a thick skin of yellow soap had formed on top. This was cut out into little squares.

"The upper part, which we are now removing, is used to make the finer kinds, and after further refining we may use it for toilet soap; but the soft, dark-colored material below may be used in its soft state, for washing clothes," remarked the Professor.

"How are we to refine these cakes?" asked George.

"By reboiling, then allowing them to become cool, and during this process the impurities settle; the top forms the refined part of the soap, which may be perfumed."

CHAPTER VII

THE DISCOVERY OF USEFUL METALS

The acquisition of the cow and calf did, indeed, impose a burden upon the colony, because the work of putting up the new home engrossed their attention at this time. It was laborious work hunting the wooden poles and carrying them to the Cataract, as they called it.

Their first hut, which was designed for temporary quarters only, was but ten by ten feet, and it was built out from the angle formed by the jutting rock, so they had only two sides to enclose and to provide a roof, which saved considerably in material, and reduced the labor. This occupied three days of hard work.

"What are we going to do about our cow?" asked George.

"I suppose we shall have to build a stable of some kind. I have an idea. Below the falls we can make an enclosure, running from the cliff wall down to the little bay, and so as to take in part of the water, and that will also solve the water problem," said Harry, as he proceeded to make a sketch of the plan.

But the boys found fence building a hard job. They could use only the small poles, because they had nothing but imperfect cutting tools, and the poles had to be carried, and then driven in by the use of stones.

The poles were six feet long, and placed six inches apart, and near the upper ends stringers or small poles were run along horizontally, and tied to the tops, to keep them together. At intervals of eight or ten feet columns of stone were built up to serve as supports for the fence. A gate was placed at one side so that it would swing on hinges, made from strips of the bearskin. When completed the enclosure was about twenty by thirty feet within.

While all this was going on the Professor urged the boys to make themselves familiar with the cow, and by degrees to show the animal that no harm was intended; to which he added:

"I believe it would be a good plan to get the calf, if possible, and lead it around, so as to show the mother your friendly intention. All animals have the instinct of fear firmly implanted in them. That makes them intractable when restrained."

The task of milking the animal was a far more difficult one than they had bargained for. By degrees they succeeded in this also, and finally the day came when they must move all their household goods and the stock.

"How shall we get the cow over there? That is what puzzles me?" asked Harry, as they were contemplating the removal.

"There is a plan that I have seen used with good results. Prepare two strong ropes, each about fifteen feet long. We can cut up part of the bearskin for that purpose. Then, we shall want another about twenty feet long. To attach them, tie one end of one of the short ropes to one horn

of the yak, and bring the rope over the head and down under the neck. The other rope is tied to the other horn and thrown over the head in the same way so it extends over in the opposite direction from the other rope.

The long rope must be tied to one of the front feet, and used as a trailer. This little sketch shows just what I mean. (Fig. 11.)

"But what shall we do with the calf?"

"We must tie that to a separate rope, and as you boys must handle the side ropes, I will take

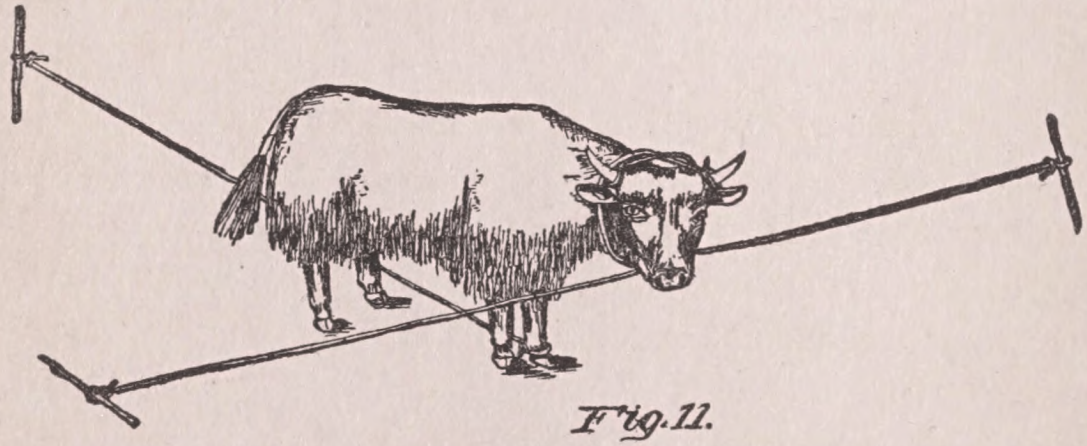


Fig. 11.

THE TETHERED YAK

the trailer rope, and also hold the rope to which the calf is attached."

All preparations were thus made, and they found no great difficulty in securing the ropes as described.

"Before we start we must attach a piece of wood to the end of each rope. Get three pieces; each about two and a half feet long, will do, and we can tie the end of each rope in the middle."

"What is that for, Professor?"

"It will serve two purposes: If, by any mischance, the cow should get away, these trailing

clubs may serve as anchors; and on the other hand, if she should become vicious you can use the clubs as weapons for defending yourselves. Are you ready?"

The ropes held by Harry and George were now brought out of the trap, the boys stationing themselves on opposite sides of the door opening, ropes in hand. The Professor was at the door which led from the other apartment, with the end of his rope, and with the calf tethered to him. Harry cautiously slipped up the trap, upon which the Professor opened his door and gently prodded the cow.

All of this preparation was sufficient, of course, to serve as a tonic for the animal, but the open door was a sign of freedom, and without much urging she bounded for the outside air. The boys both sprang aside, and in so doing their ropes became taut around their animal's windpipe, at which she suddenly stopped and with a look of surprise.

"That's dandy!" said Harry. The calf was now at her heels, with the Professor following. Once in the open air, however, the animal lost all restraint, plunging first in one direction, then in the other, but at each turn the choking motion was applied, and at the end of every effort she bellowed, each occasion being answered by the calf.

Fairly good progress was made until they sighted their home. At this point, as they were going down the steep incline, George fell, and in doing so frightened the animal, so that she plunged forward repeatedly, until she was

brought to her knees, for a moment, by the Professor. She was up in an instant, and before George could regain the end of his rope, the cow turned upon Harry, who now had no alternative but to retreat.

"Get the rope, George; get the rope," cried the Professor. It was useless. "Then get the other rope, Harry."

There was now a terrible mix-up, and the Professor's strength was about exhausted. "Come here, quickly," he called out, at which both boys rushed toward him, but before they could reach him he stumbled and the club was wrested from his hands.

The cow was free, but not the calf. Notwithstanding the bad luck all laughed at the situation.

"What shall we do with the calf without its mother?" asked George.

"Never mind about that," answered Harry. "What shall we do without any milk?"

The answer came quickly, as the cow, after running a few hundred feet, began bellowing for her calf, and as it didn't follow, she stopped, and upon seeing that there was no pursuit, meekly returned and stood quietly a short distance away.

"Capital," said the Professor. "We can use the baby to bring her back."

Surely enough; without paying any attention to her, they crossed the hill and tied the calf in the enclosure.

"Keep away, now, and we may soon capture her again. Love for her calf is too strongly developed to need much waiting, is my opinion."

Within an hour the cow was inside the enclosure, and when the boys went down she did not seem to be in any way alarmed, nor did she endeavor to get away. The calf was kept tied, and the gate of the enclosure left open. The next morning the cow was feeding on the green grass, and the boys passed and repassed without alarming her in the least.

The need of better cutting tools was now impressing itself more and more upon our colonists. As the days became cooler they were reminded that they must prepare for the cooler, or, at least, the rainy season, and this would mean a stock of fuel, as well as of provisions. The cow and calf might serve them for meat, and they still had clams. It was difficult to get fish, although they knew that the stream held a plentiful supply.

"Why can't we get some iron to make tools with?" asked Harry.

"Good suggestion," answered George. "I am off for the mines."

The idea pleased all of them, particularly the old man. They lost no time, but commenced getting all the available means they had for carrying materials and supplies, and thus equipped set out for the mines.

"I am going to give you a surprise, boys. During my investigation two weeks ago, at the time I found the coal, I came across an iron deposit, not far from the coal layers. It is fortunate that it is not far from our new home. In order to hasten things I suggest that we divide our labors.

"Harry, you take such tools as will be necessary,

and get some coal, and, George, you prepare the fuel, getting the dryest wood you can. I will select the place most suitable for our purpose."

When the coal had been assembled, Harry said: "Now, I will get the iron."

"No; we are not yet ready for that," replied the Professor.

"But we are going to make iron, are we not?"

"Yes; but we have something that is more important now."

The Professor then requested the boys to bring down several loads of clay, and as their "works" were erected near the edge of the stream they soon made up a batch of clay so that it was in a plastic state. With this clay a sort of stove was made, measuring about two feet in diameter, and a little more in height, the whole being surrounded by a layer of stones to hold it in place. At the bottom were several holes to admit air. (See Fig. 12.)

"Is the iron ore put into this stove?" asked George.

"No; we must first make coke, and it will simplify iron making."

"What is the idea of making coke? Why not use the coal itself?"

"Coal can be used direct, but it is very bad to do it with bituminous, or soft coal, and that is the only kind we happen to have on hand.

"What other kinds of coal are there, then?"

"Lignite, cannel, and anthracite. Anthracite is the only other kind available for making iron."

The stove, or oven, as finally made, was then

filled with wood, and after being allowed to burn for some time, the oven was covered with a large, flat stone, and the air holes below were closed. When the fire had, apparently, died down suffi-

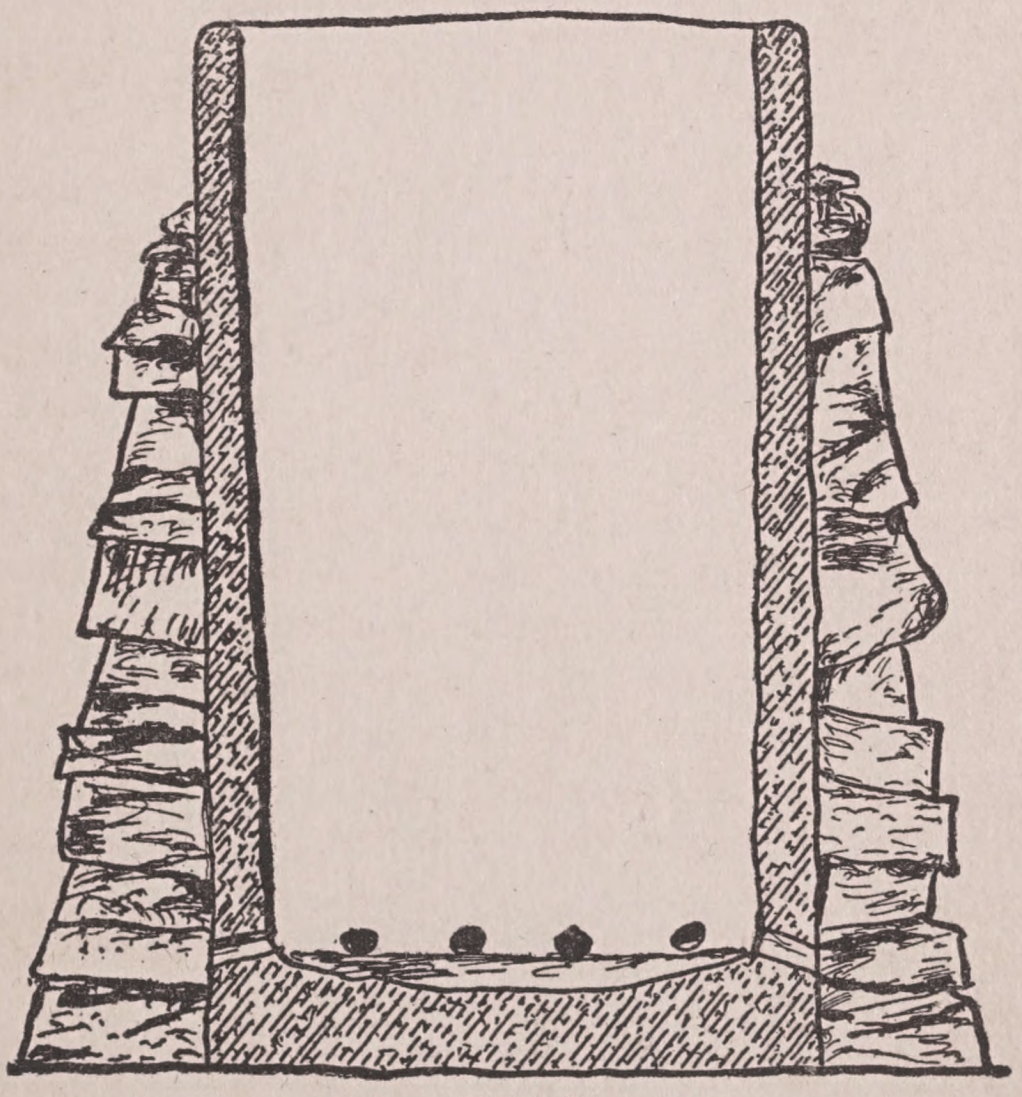


Fig. 12.

CHARCOAL FURNACE

ciently, a small hole, or opening, was made below, and also another small hole above, so that the smoke finally passed out.

When the interior was again at a glowing heat, the top stone was removed and water poured in

so that the fire was finally smothered. With a stick the black pieces were then lifted out.

"What is all this for, Professor?"

"This is charcoal."

"I thought you intended to make coke?"

"Yes; but to do so we must have the fuel best suited for the purpose. Charcoal is to wood what coke is to coal."

When they had thus burnt off several ovenfuls of charcoal, the Professor announced that they were now ready to make coke.

Without taking out the last charge of charcoal, and before extinguishing the fire, the Professor put in a sufficient amount of charcoal to fill the oven completely, on which, when it became a glowing mass, was deposited a quantity of coal, which had been broken up into fine pieces, and more was added as the charcoal burned out. Finally, a mass of the charcoal was put on top of the coal.

"While this work is going on, we may as well be mining some of the ore, as we shall need it to-morrow."

"Why not to-day?" asked George, eagerly.

"Because we cannot draw our charge of coke until some time in the morning."

"Does it take as long as that to make coke?"

"Generally, about eight hours, and you know it must also cool down, which takes a little time."

"What makes it swell up so? It looks as though it were boiling."

"That is due to the volatile gases which are generated by the heat. The high temperature

softens the coal, and the gas is then readily liberated, so that from 25 to 35 per cent. of the coal goes off in smoke."

"So there is then only about three-fourths of the weight of the coal left, as coke?"

"Yes."

A goodly quantity of iron ore was brought to the oven, in preparation for the first stage.

"See the oven cracking! Too bad," said Harry.

"We must expect that, as we have no firebrick," was the Professor's explanation.

"Why didn't we make firebrick?"

"That is what we are doing now."

"How?"

"As all clay has so many impurities in it, we must destroy them, and as heat is the greatest purifier known, we are now burning out all the dross from the fire clay of which our oven is made."

"But if it all cracks up it will be of no use to us, will it?"

"If it doesn't crack and break up into pieces we shall have to do that work ourselves later on."

"I don't understand why?"

"Because we must grind up the burnt clay and mix it with some of our regular clay, and then burn it so as to get a sample with the smallest possible quantity of impurities in it, and the result will be a fire clay."

By the time they were ready to discontinue for the day, they had a glowing mass of coals, and there was a small opening at the top from which the fumes issued. But the amount of smoke

grew less and less, until finally there was no further trace of it. Water was then poured in at the top so the fire was entirely extinguished, and the top again put on. A hole was then made at the bottom, and a small one at the top.

The next morning the boys were most eager to return, but as they were leaving the house, the Professor called attention to a number of animals across the river, slowly moving toward the Cataract.

"What do you suppose they are?" asked Harry.

"Hard to tell, but we shall probably know after they pass the underbrush this side of the hill."

They all waited anxiously to learn what the uncommon sight could mean. In a half hour or so they had the satisfaction of seeing a herd of yaks leisurely move down the hill, heading straight for the Cataract.

"Wouldn't it be fun to capture the herd?" asked George.

"What could we do with them? They would be too much trouble," answered Harry.

"They would be of immense service to us," responded the Professor. "Their wool could be used to great advantage, and they would take care of themselves, if we could only domesticate them."

"I wonder what our cow will do?"

The boys went to the other side of the house, and watched the cow, which was feeding below the enclosure. She soon began to bellow, and was answered by the herd. She made no demonstra-

tion, however, and in a half hour more the whole lot were across the river.

It should be stated that when the question of feed for the cow was first an important topic, the Professor suggested that tubers of various kinds would be the most acceptable article of food for her, and later on, they made it a part of their duty to gather the cassavas for that purpose.

The animals in their native state, are unable to get at the roots, but they crave them, when they once get a taste of them, and that was the case in this instance. The cow became so accustomed to the daily feed that she would come to the house in the evening, if her regular feed should be neglected for a time, and would not go away until she had received her portion of the succulent roots.

"George, get some of the cassavas, and let us take them over the river. That will bring them."

"They will run away, if we go over," he answered.

"I think they will come back. The suggestion is a good one. If they once get a taste of them, the herd will belong to us, sure," responded the Professor.

The roots were taken across, and the herd retreated. After depositing them on the ground, the boys returned to the other side, where they waited to see what they would do. The most daring of them soon moved up, and when they began feeding, the others came up, and the boys congratulated themselves on what they believed would be a most valuable acquisition.

When they arrived at the oven they took off the top cover, but in attempting to remove the coke their clay-lined oven was practically destroyed. All the clay thus burned was carefully put aside, and a quantity of it crushed. All of this work required infinite pains, but it was a labor which absorbed every moment of their time, and kept up the interest to an intense degree.

Fresh batches of clay were now brought forward and made up, to which was added a large quantity of the fresh burnt clay, and a new furnace, somewhat similar to the first, was built, although it was higher and the walls considerably thicker.

"If you will notice, boys, the bottom of this furnace becomes narrower, or is contracted as it deepens, and it has sloping sides."

To afford a clearer idea of how the furnace was made, look at the drawing (Fig. 13). This furnace was entirely made up of clay.

The Professor continued: "Leading out from the contracted bottom are two or more openings (A A), and these holes are larger at their outer than at their inner ends. A cone-shaped projection (B) rests on the bottom, and has a vertical hole (C) through it, which connects with a horizontal hole (D) so as to admit air to the cone. The air is distributed in all directions through many holes (E) near the top of the cone."

"What is the idea in making the holes tapering?"

"To supply air to the fuel at first, and afterwards, when the metal has melted, the clay plugs,

previously put in, can easily be taken out or replaced."

The first step was to throw charcoal into the furnace, which was ignited, and when it had reached a white heat, a layer of iron ore was

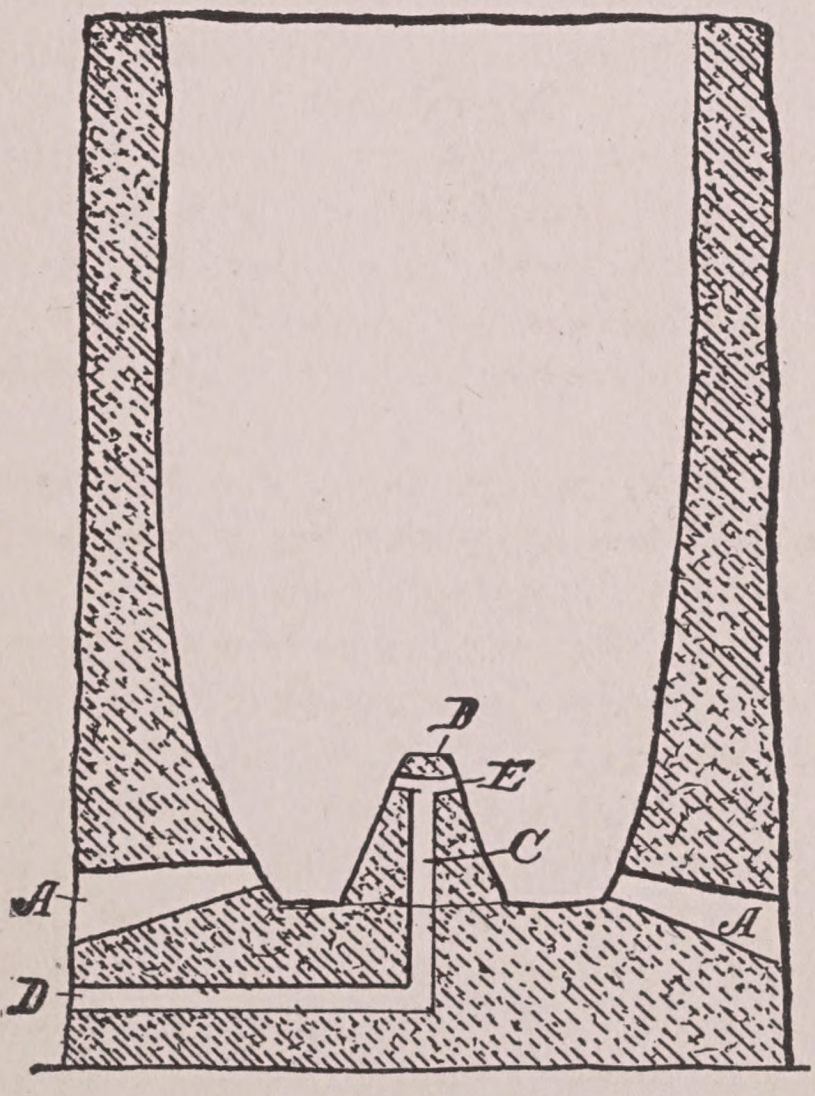


Fig. 13.

IRON SMELTER

thrown in, followed by successive layers of iron ore and coke, until the furnace was filled, the coke and ore being added slowly, so that within a short time the entire charcoal layers were burning fiercely.

During this time the holes (A) were open and through these the boys watched the process breathlessly. Within an hour George noticed a small stream of liquid running from one of the holes (A). The Professor, too, noticed it.

"We must now close the holes with soft clay. Push in the ball of clay with the end of a pole, and it will tightly pack in the tapering hole. You will now notice that all the air for combustion must go up through the center hole (C)."

Within the next hour a small amount of molten liquid was noticed at the hole (D) which led up to the cone.

During the smelting of the ore, preparations had been made, adjacent to the furnace, to receive the metal. A clay bed was made, in which were various depressions of different shapes, some being in the form of hammers and hatchets, and others were short, round sections to form bars, or handles, for tools. A few of them were shallow, flat depressions, so that something similar to sheets or plates could be formed by the molten metal, and one of the forms was an anvil-shaped hole.

All these hollows were connected up to a channel-way which led from one of the tapering holes of the furnace, and the process will be understood by examining Fig. 14.

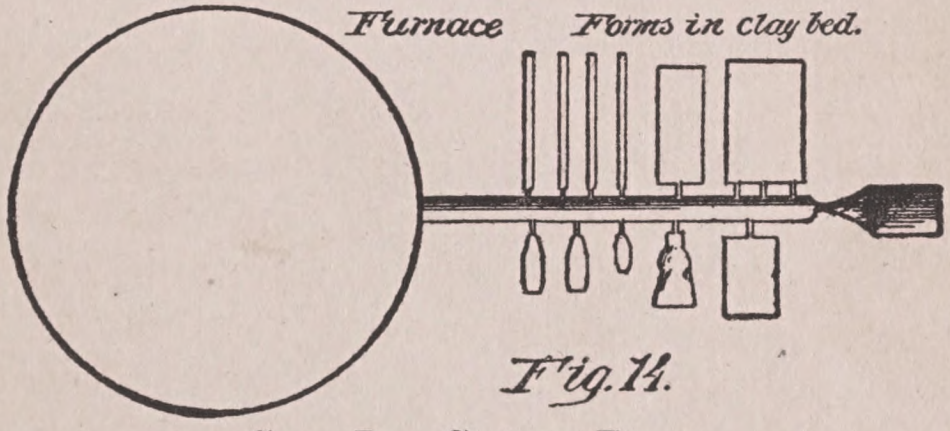
"I think we are ready now to draw off the furnace," said the Professor. All was excitement now.

"Shall I pull out one of the clay plugs?" asked Harry.

"Yes; but be ready with another clay ball to put in the moment I give the signal. Now, understand: We must run off just enough to make some of these handle shapes."

As the metal flowed out the Professor stood ready with balls of clay to direct it into the molds having the handle shapes, each of the shapes being about an inch in diameter and eighteen inches long.

"Close it up," said the Professor. "Now, have some water handy, George, as we must cool these



CLAY BED CASTING-FORMS

handles as quickly as possible. Wait until the dark red color disappears. Now; sprinkle a little water on; still more. There; that will do. Plunge them into cold water."

When the handles thus cast were taken from the water, the boys danced about at the sight of the first casting.

"Isn't that a fine specimen?" said the Professor, as he held up two of the pieces and struck them together. "How they ring! But we must not flatter ourselves with the idea that we have good iron at the first trial. The iron may be too

soft, like wrought iron; or it may be too hard, like cast iron; but both forms will be very useful."

"Why should it be either cast iron or wrought iron?" was the inquiry.

"If the sample we have here is somewhat free from impurities, and we have a small amount of carbon, we have wrought iron; but if it still has impurities and an excess of carbon, it will be cast iron.

"But can't we make steel from it if it is either cast or wrought iron?"

"Yes; if it turns out that there is considerable carbon in it, we must free it of the impurities, such as slag and oxides, and that will then give us steel."

They were now ready to tap off the remaining charge. The tap hole was opened and the metal flowed into each of the depressed portions in the bed. While the cooling process was taking place, the Professor took the cast handle forms, which had been previously cooled, and pushed one of them down through the molten mass in each of the hammer forms, the same as the handle is usually pushed through the eye of a hammer.

"That's a clever way to make a handle to a hammer," remarked George.

Within half an hour the castings had been cooled down so they could be raised up from their beds. The handle castings, which had been allowed to remain in the molten heads, were now held firmly therein by the metal, as the latter shrunk in cooling, but, of course, the handle and hammer were both very rough.

"There," said the Professor, "we have one of the most important tools in the hands of man—a hammer. With this we can fashion almost anything."

When they returned home that evening, Harry's intuitive mind was quick to assert itself. "We must have a real grindstone now."

"That is a wise conclusion," replied the Professor, "and it is in the proper direction to commence the work of making tools."

During the following day the boys were busy making a frame, on which to mount a stone, and

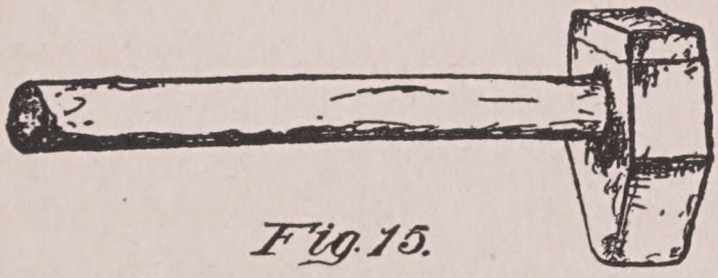


Fig. 15.

THEIR ORIGINAL HAMMER

now the first task was to finish one which would really do the work of grinding. A suitable stone was found for the purpose, and the first thing was to drill a hole through it, which was a comparatively easy task, with the metal pieces.

When this was done it was mounted on the frame, and a suitable crank provided. It required hours of work grinding down the rough and projecting edges, which was done by allowing other stones to come into contact with it while being turned.

When it was finally turned down so that it was fairly cylindrical in form, the hatchet blade was fixed to a frame, and put at a proper tangential

angle, and gradually moved toward the stone so as to wear down the projections and inequalities, thereby making the surface not only sharpen the hatchet, but also true itself.

The large pointed block of metal had one side and a pointed end ground up so as to form an anvil.

"I am disappointed to find that while we have made a good sample of wrought or malleable iron, it is too soft for cutting purposes," said the Professor.

"Then we must make steel, I suppose," replied Harry.

"I can see no other remedy," he answered.

"Will that be difficult to do?"

"No; with the metal we now have, and the charcoal we still have on hand, we can probably puddle the iron."

"How will that change the iron so as to make it steel?"

"The iron we have is very pure, but it is low in carbon, and its softness shows that we have less than one-half per cent. of carbon in it. If we now can fuse—that is, melt the iron with a fuel intermixed with it, the fuel, if it is charcoal, for instance, that will put an additional one per cent. of carbon in it, and we shall be able to get a steel that will be serviceable."

This was sufficient again to awaken the boys to activity, and during the day another furnace was built and charcoal used for melting purposes. Great was their delight at the product turned out. The puddled iron, or steel, was actually boiled

in the furnace, and then allowed to become cool until it was pasty.

"Is it not possible to get too much carbon into it?" asked George.

"Yes; that is frequently the case."

"Doesn't that really make it useless as steel?"

"Not by any means; if such a thing occurs the steel becomes brittle, something like cast iron."

"How can the brittleness be overcome, or remedied?"

"That can be done by heating and then cooling it repeatedly, which will remove the brittleness, and make a very tough metal."

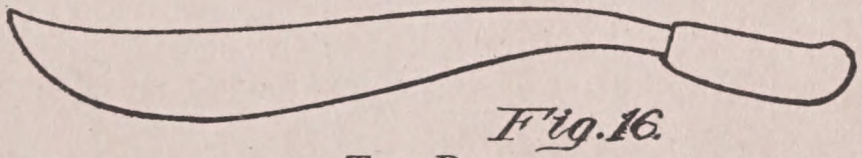


Fig. 16.

THE BOLO

The steel produced was of fairly good quality, and they were now able, for the first time, to set about the work of making necessary tools, such as blades, which they forged out of the small ingots that had been cast from their steel-charged furnace. But their ax and hatchet were still imperfect, because they had no means of making the eye, wherewith the handle could be attached.

"I only wish we had an ax, or a hatchet," said Harry, one day.

"Why don't you make a bolo, instead?" asked the Professor.

"What is a bolo like? Is it in the form of a sword?"

"No; it is something more like a butcher's

cleaver. It is the form of a hatchet, or ax, used by all primitive races who are able to recover iron but have no extensive tools to enable them to make holes through the metal. The bolo is a Bisayan weapon, in the Philippines, and is somewhat like the Cuban machete."

That was a comparatively easy task for Harry, and the specimens he turned out were truly wicked-looking instruments, and terrible weapons for defense, in case of attack.

With these they had no trouble in felling fairly large-sized trees, and they were particularly handy in hewing logs, or facing off the timber which was needed for their home.

CHAPTER VIII

THE FIRST EXPLORATION

THE building of a home was the first task. It was laborious work, even with the newly acquired tools. Each day Harry improved the form of the tools the better to adapt them for their work.

"What is the most useful tool?" said the Professor.

Harry pondered, and then replied: "The bolo, I think, but a saw would come in very handy."

"In time you will, no doubt, be able to make one. Unquestionably, the bolo, or the machete, has a more useful function than any other tool. It is available to sever material, or trim and smooth it, so that it is a tool which is a substitute for the saw and the plane."

The most important want, now that their house had been completed, was clothing. What they had was growing shabby, and they needed bedclothing, as leaves imparted no warmth.

"We have so much fiber on hand that with our tools we should improvise a loom, and do like our grandmothers used to do, spend the early evenings in weaving."

"Then let us commence at once. What is the first thing to do?"

"The shuttle is probably the most difficult to make, and I am going to make a drawing to show how it is made. In the sketch (Fig. 17), you will

see that it is a long, round piece of wood, tapering or pointed at both ends, the body (A) being hollowed out, and having at one pointed end a small hole (B) for the thread to pass out. The other end has a plug (C) with its end pointed, and this plug fits into the hollow of the shuttle. It has an inwardly projecting piece of wood (D), which is the bobbin, or quill, on which the yarn or thread is wound."

"Oh, yes, that is the woof."

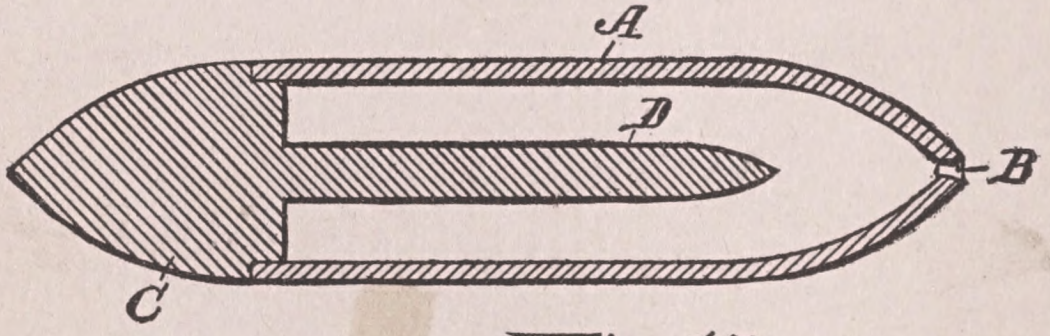


Fig. 17.

THE SHUTTLE

"No, the weft. The woof threads are those that extend lengthwise of the goods, and the warp threads are the crosswise ones."

"As I haven't anything to bore the hole with, it is pretty hard to make the shuttle. If I had some glue I might make it without trouble."

"Then we shall make some glue. We are fortunate in having plenty of fish for the purpose."

"Is it very difficult to make?"

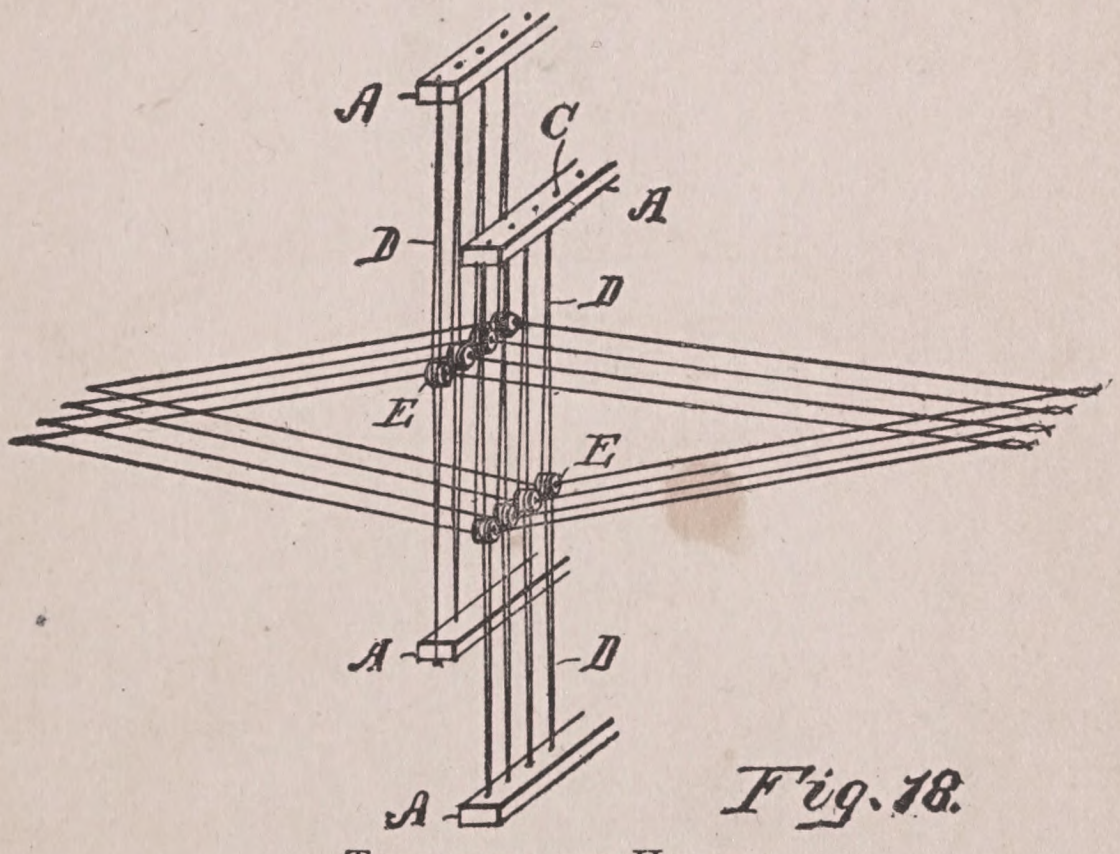
"It is rather simple. Boil the fish until it is entirely shredded; then allow it to cool; and the glue will then come to the top. We can refine it by reboiling the substance thus obtained, and finally get a very good article."

"Is fish the only thing we can use?"

"No, we may, later on, use the hoofs of animals, as well as the hide."

It did not take long to prepare the glue, and a very serviceable shuttle was made.

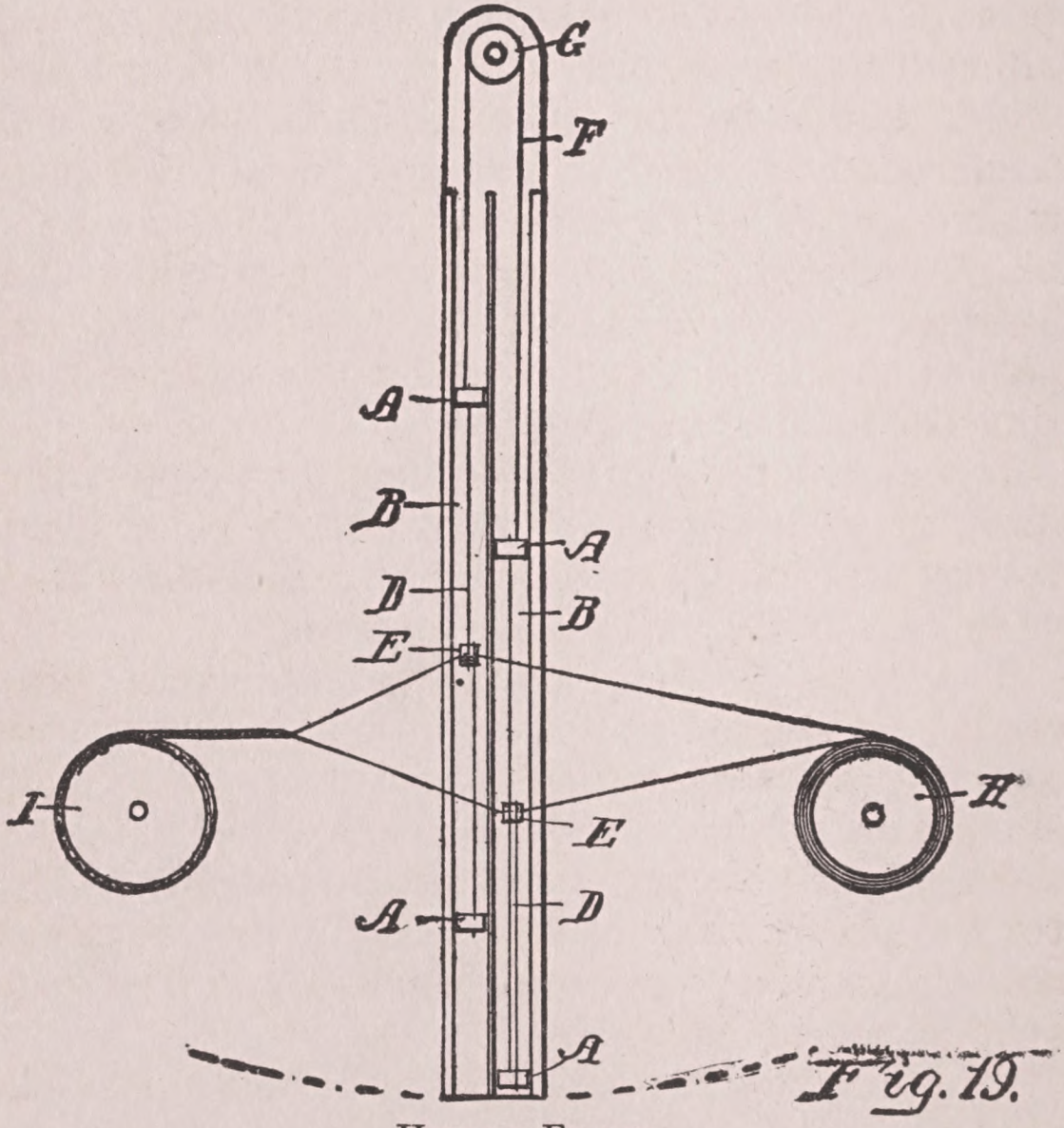
While the glue was being prepared the Professor instructed the boys how to make two heddle



THREADING THE HEDDLE

frames (see Figs. 18 and 19), each of which was made of a pair of horizontal bars (AA), held together at their ends by short vertical bars (BB). This heddle frame was three feet long. A row of very small holes (C) was formed through the upper and the lower bars, and loops of ramie fiber thread (D) were threaded through the holes, so that the loops of the threads met midway be-

tween the bars, and these loops were secured around little eyes (E), which they made out of short sections of bamboo.



HEDDLE FRAME

These heddles were mounted in a frame, and suspended by cords (F) looped over pulleys (G) mounted on the frame, so the heddles could move up or down alternately, as shown in Fig. 19.

A yarn roller (H) was then mounted behind

the heddles for the warp threads, and a cloth roll (I) in the front of the heddles.

In threading up the heddles one thread is passed through the eye (E) of the heddle, the next thread through the eye of the next heddle, and so on, alternating, as shown in Fig. 18, so that when one heddle is up the other heddle is down, and a triangularly formed raceway is formed between the two rows of threads through which the bobbin is passed in one direction, then when the heddles are reciprocated the bobbin is again passed back, and a new thread is thus added each time the heddles are changed.

It was a long and tedious task to prepare the fiber, as each strand of warp had to be at least twenty feet long, and to make the cloth three feet wide required a great many strands.

The work in their inexperienced hands proceeded slowly, but the cloth, although coarse, was certainly a good, serviceable product. They had started an enterprise which, while it did not give them a great variety of cloth, served admirably for the present as clothing, and for the innumerable things which are needed in order to live with any degree of comfort.

"We are letting our cataract water run to waste," said Harry, one day. "We could make so many useful things if we had power."

"Then I suggest," said the Professor, "that we build a water wheel, and probably we can succeed in forging out a saw blade. If we are successful in that there will not be much trouble in rigging up a jig saw for cutting our lumber."

"And with that we can put up our factory," said George, enthusiastically.

"What kind of water wheel shall we make?" asked Harry.

"I think an undershot wheel will be the easiest to make and the simplest to mount, although it is not the most efficient and is the most difficult to control."

"What other kind could we make?"

"We might construct a turbine."

"What is the difference in principle between the undershot and the turbine?"

"The undershot is dependent for its power on the speed of a moving or falling stream of water, whereas the turbine depends on the head or the pressure of the water. The undershot wheel is difficult to control as to speed, but the turbine can be regulated to run at any speed."

"Then why not build a turbine?"

"My objection to that is, we must build a flume and a penstock, to carry out and hold the water. With the undershot wheel that is not necessary."

"Then let us have the undershot."

The cataract had its main channel on the side nearest the home, and about ten feet from the shore were several large rocks around or past which the water flowed. It was agreed to make an attempt to mount the wheel on timbers secured to those rocks and to similar rocks on the shore side. (See Fig. 20.)

A straight tree trunk (A) was used for the shaft. This had four pairs of arms (B), and blades (D) were secured to this. Intermediate

were other blades (E) attached to arms (F), and held in place by side bars (G). A wheel (H) was

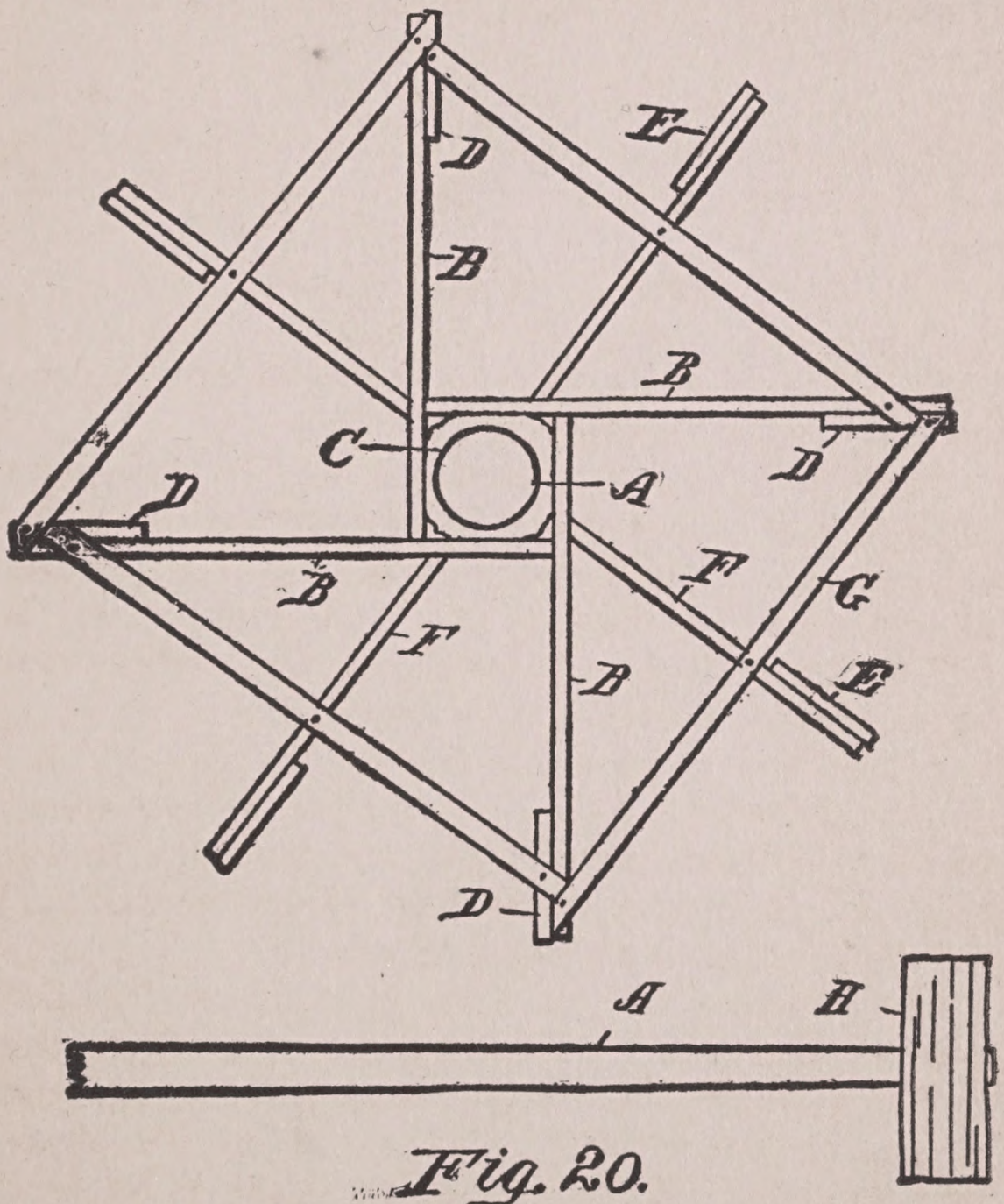


Fig. 20.

UNDERSHOT WATER-WHEEL

put on the land end of the shaft to turn the machinery.

They immediately began the building of the frame for a saw, and with a patience and deter-

mination which would be a pattern for many men, they hammered out a blade of steel three feet long. Of course, it was thick and rough and when completed Harry was at his wit's end to know how he could form the teeth, as their steel was very hard.

The Professor was amused at his perturbed state of mind. "I suppose we could turn the steel into malleable iron again?" he said.

"Well, we might just as well have made it out of malleable iron in the first place."

"Then it would have been useless for our purposes. Instead of that, let us anneal the steel blade you have."

"Will that make it soft?"

"Yes, and then we can harden it again. That is called 'tempering' it."

Accordingly a furnace was built, long enough to take in the blade, and coke was put in, spread out and ignited. When it was a glowing mass the blade was laid on to heat.

"When it reaches a temperature of about 1,300 degrees of heat, we must remove it and cover it with ashes until it is entirely cooled down."

Harry laughed, and said: "How shall we know when we have that temperature?"

"That is told by the color. When it first shows signs of turning red we shall have a temperature of 1,000 degrees of heat; a dull red, 1,300; cherry red, 1,700; deep orange, 2,000; and white, 2,400."

"Fine," said George; that is worth knowing."

But their troubles with the saw were not over. Teeth had to be cut, and that without a file. True,

they had made what is called a "cold chisel," a very hard steel cutting tool, and with that they cut out tooth after tooth on the thickest margin of the blade.

"The blade is finished and it is ready for tempering," said George. "What is the next step?"

"Let us heat it again, so that it shows a nice cherry red. Then plunge it into cold water so that it is suddenly chilled."

When this was done the Professor held it up at one end and struck it with a piece of metal. It had a highly pitched ring.

"If it had given out a dull ring we might be sure it did not take the temper," he said.

The next step in the preparation of the saw was to rig up a small thin-bladed grindstone, and with this each tooth was filed to a sharp point; and then on the large grindstone they spent the greater part of a day in smoothing down the irregularities of the surfaces of the blade. Before they tempered the blade they had formed a pair of holes at each end of the saw so as to provide a means for attaching it to the frame.

The frame, which was vertically movable, to hold the saw, was the next thing to prepare, and was mounted in the stationary support of the sawmill. A horizontal shaft was placed below the saw frame, one end of which carried a small pulley, in line with the large pulley on the shaft of the water wheel. The other end of the horizontal shaft had a crank. A bar of wood, called a pitman rod, was then attached at one end to the crank, and the other end of the pitman was secured

by a pin to the lower end of the saw frame. By this means, when the crank turned, the saw frame would move up and down.

You may be sure that this primitive sawmill was not only a source of great delight, but it was the means of greatly lightening their labors. The work fascinated the boys. They were learning to do things of value.

One evening the Professor said: "My boys, we have worked hard, and it might be well for us to have some recreation. I propose a day of hunting and exploration. We really do not know our domain yet, and we might learn some things of value to us before the rains set in."

"For my part, I am anxious," said George, to go through the forest."

"Well, I should like to see the big river which George discovered to the south of us."

"Capital idea. Why can't we build a boat and travel in that way?"

"Your ideas are all right, since this must be a very large island."

"Why do you think so?"

"Because of the large river which George saw."

"That is true. If it is a large river it must take considerable territory to form the stream."

This opened a new field of activity. To build a boat meant time, but with the knowledge that it would enable them to form and carry out their pet project of exploring the country, they worked day and night in cutting out the material and in shaping it into form for their first boat.

It was about sixteen feet long, and nearly five

feet wide, with a flat bottom, so that it was really a staunch vessel, and adapted for their purpose, safety being the first consideration. They made up some leaf mattresses which they stowed away at the rear end of the boat, and constructed small cupboards at the sides for their provisions.

"What bothers me is to find out how we can keep the boat from leaking. I know we cannot safely launch it unless we fill up all the cracks."

"Well, Harry, it would be a good idea to caulk it. We can do it with oakum. You saw that used on shipboard."

"But we haven't any oakum, and nothing to make it with."

"Don't you remember the little blue flower you found on the hillside when we returned from Observation Hill, several weeks ago?" You will find a lot of that all around here. Gather a good load of that, and we shall see whether we need to worry about caulking."

"What is the plant?"

"A species of wild flax, which will be a first-class substitute for the oakum."

"Is oakum made from flax?"

"It is the coarse part of both flax and hemp; but we shall use the entire stalk for the present job. It would be better, if we had the time, to treat it as we have been doing with the ramie."

"Why couldn't we use the ramie just as well, because we have a lot of that on hand?"

"You have forgotten, probably, that ramie resists moisture, and for caulking purposes we must

have some material that will absorb moisture to a greater or less degree."

"Why should it absorb moisture if it is intended to keep out the water?"

"If the material we put in absorbs moisture it will swell, as is the case with flax or hemp, and by that means it will make the packed seams tighter, and so help in keeping the water out."

It was not much labor to get the flax, and after trimming off the leaves and tops the entire mass of stalks was broken up, because the lateness of the season had turned the stalks to a dark yellow color.

"It would be prudent for us to gather quite a lot of the flax before we set out, as we can put in some time during the rainy season in working it up. If we wait until we return, the flax may have rusted, and so become less valuable, if not useless."

When the flax had been broken up so as to make a rough fiber, the worst part of the woody refuse was sifted out, and the work of caulking the boat was commenced. This was done with a small blade, blunt at the ends, by means of which the flax was driven into the cracks. When the boat was finally launched the water showed itself at many places, but the Professor assured them that when the wood and the flax had absorbed sufficient moisture the swelling of the material would be sufficient to exclude the water.

During the next few days they were busy preparing the articles necessary to take with them on their journey of discovery. First of all they

prepared and put into convenient places sufficient arrows for all emergencies, and in addition they made some heavy spears for defensive purposes.

And now came the greatest problem of all; what to do with the cow and the calf. They had not made any preparation to keep the animals during the rainy season, and so it was thought wise to free them, as they felt that they would be able later on to capture others to take their places. The Professor suggested that they might slaughter the animals, and thus enable them to lay in a stock of meat, but the boys could not bring themselves to kill them, as they were very tame and became great pets. So they were turned loose before their departure.

The day for starting arrived; they said good-bye to the cow and calf, and launched their boat at the beach. It had been equipped with a sail mounted on a single mast, so that it was easily managed, under the instruction of the Professor, and after skirting the beach southward for several hours they entered a bay, the incurved shore of which they followed for some time.

"There is the river," said George, enthusiastically. Surely enough, to their right, was the mouth of a rather wide stream which appeared to run westwardly, and to this our voyagers directed the boat.

"It might be well," said the Professor, "to observe the utmost caution as we proceed. We must have a common understanding, in case of danger. Thus far we have had no knowledge of the presence of human beings, but as we go into

the interior we may find people who are likely to bar our progress."

"I think you ought to be the captain of our expedition, and we should always be guided by your advice," said Harry.

"On the other hand," said the Professor, "I am of the opinion that one of you should take the lead, and I will act in an advisory capacity."

To this suggestion the boys would not agree, so the Professor called the first counsel, and said: "Since you have made me commander-in-chief, I would make these suggestions: First, that whenever we land, neither of us shall make any journey away from the boat on his own account. We must always keep in touch with one another. Secondly, always keep your arms of defense in condition and ready for use. Third, one of you must be the lookout, while the other keeps his attention to navigation. This can be done in turns, so that each will become accustomed to the duties of the two positions. Fourth, we must not on any account build any fires after the sun goes down, as we might thereby attract the attention of enemies, should there be any."

The stream was by no means rapid, but it took many turns, and George, who was the first lookout, was constantly pointing out the many new scenes which they passed during the first two or three miles of their journey. Perceptibly the current in the river grew stronger, and they were compelled to hug the shore in order to be able to make any headway.

"It seems to me we are about at the end of our journey," said the Professor.

"And why?" said Harry, depressed at the intelligence.

"The appearance of the stream leads me to believe that we are approaching a falls, or a portion of the river which makes a rapid descent, or the stream would not be so swift."

"Then let us get to the falls, at least. We can row the boat, at any rate."

In fact, oars became necessary, and although they made numerous stops for rest, they found the task a most trying one. It was past midday when, almost tired out, they sought a suitable landing place for the noonday meal. After a long rest they again took up the oars. Gradually the work became harder and harder and the progress slower until, rounding a bend, they were surprised and delighted to find themselves facing in the distance a beautiful falls, the rumbling sound of which they had heard before they made the turn.

"What shall we do now?" said George.

"Take the boat around the falls," said Harry.

"That would be impossible," said the Professor. "It would take days to do that, together with all our supplies. We must elect to go forward on foot, and carry such provisions and ammunition as we can, or else return."

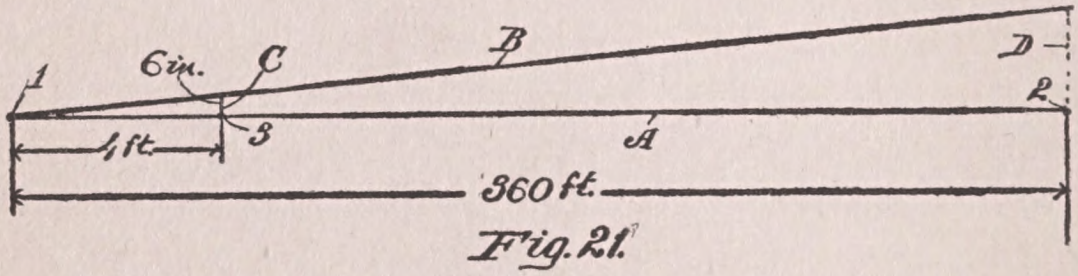
"Let us go on, by all means," said George, and this sentiment was seconded by Harry.

They accordingly approached as near the falls as possible, and a safe mooring place was selected.

The boat was drawn up and securely fastened, and the provisions and ammunition selected for their journey.

"If possible, let us try to gain the height before it is dark," said the Professor, "as we must make as much haste as possible, now that we have to depend upon our legs to carry us."

"How high do you think it is to the top of the falls?"



MEASURING HEIGHTS

"We might measure it," said the Professor.

"But where shall we measure it from?"

"This will be one of the points; but we must have another point to measure from. Knowing two of the points we can easily find the other point."

"Why are three points necessary?"

"Three points are not necessary in order to measure a distance, but if the point you wish to measure is not accessible you must substitute something for the unknown point, and then by using two other points the unknown can be ascertained. This method is known as the triangulation system."

"What is the first step necessary?"

"To find the length of one line. First measure the distance from where we are to the falls, and

we will call that the base line A. Now, with your tape line, measure off the distance as accurately as you can."

The boys did so, and as nearly as they could determine, the length of the base line (from 1 to 2) was 360 feet.

"Now have we a straight edge, say, two or three feet long? I don't think we have anything but this oar, which is rather straight."

"That will answer admirably. We will now stretch a horizontal line, using your tape measure for the purpose, so as to represent the base line which points, as you will see, to the base of the falls. One end of the oar is now put at the end of the line (at 1) and pointed to the top of the falls. This gives us another line (B), which is called the angle. Now, George, measure off, say, four feet along the base line and make a mark. (See numeral 3.) From this point measure up to the angle line B and get the exact distance."

"It is just six inches, Professor."

"Suppose, now, we call that line C. This line C, therefore, gives us the height of the falls."

The boys laughed at the absurdity of this statement.

"By itself the line C does not give you the true height of the falls, but taken in connection with the two other lines, it gives the height just as accurately as though you had measured it with your tape line. In other words, the height of the line C, from A to B, is the same proportionately as the height of the line D is from A to B. You may now figure this out and see."

"Very well," said George. "It is done by proportion. Let me see: Six inches is a half foot, so the statement will be, 4′ : ½′ :: 360′ : ( ). Multiplying the means, ½ by 360 is equal to 180; and dividing this by 4, is equal to 45. So the falls would be 45 feet high."

"I would do it in this way," said Harry; "360 is 90 times 4, so that makes the distance from 1 to 3 one-ninetieth of the distance from 1 to 2. The vertical line C from the point 3 is just six inches, so that if one-ninetieth is multiplied by six inches, or a half foot, it will show that the vertical line which extends up from the falls at 2, is 45."

"Either method is correct. But we are losing time. If we are ready let us start."

As they advanced the ground became more and more broken and rocky, and the way was also more or less impeded with shrubs and bushes, so that it was fully an hour before they could make their way to the top of the plateau which now lay before them.

As nearly as they could estimate they were fully fifteen miles from their home, although to reach that point by way of the river was much farther. The woods which they had penetrated some weeks before was to their right, and to the left what appeared to be a mountainous, or a highly elevated, plateau. They decided to follow the course of the river, but they were now on the north side of the stream, and from their position were able to see that the other side of the river was comparatively free from large timber. But everywhere was the inevitable bush and shrub growth.

"Why is it," said George, "that the forests do not come down to the ocean? It seems to me that all this land should be covered with big trees, instead of the little trees we see everywhere."

"I am glad your powers of observation were great enough to notice that. Can you not think of a reason why so many places on our island are comparatively bare?"

"I don't suppose it is on account of the soil, is it?"

"No; that wouldn't account for it."

"I think fire has burnt out the woods," said Harry.

"You have, in all probability, given the best reason."

"But if that's the case then the island must be inhabited."

"That is one conclusion. On the other hand, the island, at some time, may have been visited by ships' crews, and the fire started in that way."

This information was not a little disquieting to the boys, but it served to add zest to the determination to find out what the island contained.

When night came they were ready to seek a camping site, for they were tired and hungry.

CHAPTER IX

MAKING THERMOMETER AND OTHER INSTRUMENTS

It was not a difficult task for our adventurers to prepare their meal, as they had agreed not to make a fire at night, and when they had finished their repast a sheltered spot was selected, and wood and brush prepared for their night's habitation.

During the night they heard many unfamiliar sounds, but nothing to disturb them. Early the next morning they were up, and Harry was the first to skirmish around in the near vicinity. On every side he found berries and nuts of all descriptions, and he was particularly pleased to find a grove of blackberries, of which he gathered a sufficient quantity for breakfast. They were keenly relished by all the castaways.

As soon as they were refreshed they took up their journey, which carried them gradually upward to a higher table land, and before noon they had passed the forest on their right and the landscape presented called forth expressions of delight.

As they were crossing one of the little brooks which fed the main stream, they were startled by the tramp of animals, splashing through the water at their right. There was a small clump of underbrush near by, and to that they instinctively made their way.

"Some more of our cows," said Harry. Truly enough, the herd, which had been disturbed, was crossing up the slight incline on the other side of the stream and they had a good view of the animals.

"It seems that we have a large number of those beasts," said George. "I wonder if there are not others of their kind around?"

"You may be sure," said the Professor, "that we have not yet found the real animals."

"I have often wondered since we came to the island why we haven't seen more animals than we have."

"You must remember that we have not gone very far from the seashore."

"But, Professor, why don't they come to the seashore?"

"As a general thing they stay where fresh water is abundant, and the sea does not attract them. For this reason wild animals are always found in the interior, where also they have more protection."

"Look at this path, Professor; do you suppose it was made by animals?"

"It seems to be. But we might examine the tracks more closely. Ah, I see some tracks here that were not made by the cows."

"What are they?" exclaimed both boys eagerly.

"Some quadruped without a split hoof. But stop, this is getting interesting!" The boys were now alert. They could not understand the Professor's interest in the path.

"I believe, from the indications, that we may

soon have the pleasure of getting acquainted with several kinds of animals unlike our cows."

"As we are at the present time in the business of finding out what lies about us, we may as well follow up this path."

"But that will take us from the river."

"So much the better."

"Be quiet, I see something. It moved that bush yonder," said Harry, in a suppressed tone. He fitted an arrow to his bow and stooping low crept forward. When he had advanced about twenty feet he drew the bow and shot. Something dropped to the ground through the leaves, and both boys sprang forward. When they reached the spot nothing was found but what appeared to be a spiked ball.

"What is that funny-looking thing?" asked George.

"We might have some fun if we only had some water near. Don't touch it, because I see you haven't hit it." Harry was very much disappointed, of course, at his poor marksmanship.

"Shall we use some of the water from the pouch?"

"I had quite forgotten that," said the Professor. "Certainly. Pour a little over him." George did so, and to their surprise an animal unrolled itself.

"This is a hedgehog, and it plays the possum, only it is not so smart as the possum. You see, the water surprised him; the possum couldn't be fooled in that way."

"Is he good to eat?" asked Harry, eagerly. "If so, we must have him for dinner."

The hedgehog did make a good meal, and there was enough left for several meals.

This is the way in which they roasted the hedgehog: It was first dressed and then mounted upon a stick about three feet long, so that the body of the animal was practically wrapped around the stick, which was of green wood, so selected because it would not readily burn. Two posts, with forked tops, were driven into the ground, two and a half feet apart, and the stick with the animal, laid on the two forked posts. A fire was then built below the hedgehog, and the stick was turned slowly.

This method of cooking animals and fish is very common among South Sea Islanders, and meat cooked in this way is most delicious. It is the original broiling process.

That afternoon, while passing through a sort of open forest, along which the trail led, they sat down on the trunk of a fallen tree, for a brief rest. George's inquisitive nature could not be kept quiet, so he strolled to the left, in the direction of a number of trees which attracted his attention. In a few minutes he rushed back, with the startling announcement that he had seen a man in a tree.

This was indeed news of the first importance.

"Did he see you?" asked Harry. "What did he look like?"

"He was in a tree, and looked down at me without saying a word."

George pointed to the tree, and without further words they cautiously moved toward it.

"There, he was on that tree. See that limb to the right? He was sitting there."

"Are you sure of it, George?"

"I could not be mistaken."

"Probably it was only your imagination. Did you see the tree from this identical point?"

"Yes, there he is now; see him on the tree to the right?"

"That is an Orang-outan."

"My, isn't he a big fellow! Is he dangerous?"

"Not in the least. They never seem to defend themselves."

"What is he doing there? See him pulling off the branches? How queerly he acts!"

"He is simply building a seat for comfort."

"Building a seat? How amusing!"

"There, see how cozily he has seated himself. That is the only kind of house he has. They will weave a seat within the space of a minute, and do it very deftly. If we could catch one of them, or a young one, it could be easily tamed, and they are very affectionate animals. There are many in captivity, and have been taught to make their own beds, to handle a cup or saucer, and a spoon, and some of them even exhibit human ingenuity."

During that afternoon they saw quite a number of the same animals, but they were no longer frightened by them. Many of them are five feet tall, and their arms are so long that their hands almost touch the ground when they stand erect.

The weather was now getting a little cooler, and as nearly as they could calculate the time it was

about the first of March, during which time in the northern portions of the United States the weather is still unsettled. In the south temperate zone March corresponds, in point of temperature, with September in the north temperate zone.

"If we have not lost all calculations this is the first day of March, and assuming that the winds and currents here do not affect the temperature, autumn begins to-day," said the Professor.

"Does autumn begin on the same day in all countries in the north or the south temperate zones?" asked George.

"In the north temperate zone there is a difference between the eastern and western shores of the continents. In the United States, west to the Rocky Mountains, spring, summer, autumn and winter begin in the months of March, June, September and December, respectively; but on the Pacific Coast those periods are one month earlier. The same is true on the western coast of Europe, where the beginnings of the seasons are February, May, August and November."

"And why should the seasons be earlier on the western coast?"

"Principally on account of the ocean currents, which carry warm air to the western coasts."

"I know that the Gulf Stream is a current which flows from the Gulf of Mexico diagonally across the Atlantic and strikes Europe north of England, but I did not know that the Pacific had a gulf stream also."

"Yes, the gulf stream of Japan, called the Kuro Sivo. That flows diagonally across the Pacific

and strikes Alaska, and from that point it moves southwardly along the entire western coast of the United States. As a result the coast of the State of Washington is warmer in winter than North Carolina is on the Atlantic coast, notwithstanding North Carolina is fully one thousand miles farther south than Washington."

"But how is it possible for the water to keep its heat while the stream is going that long distance?"

"Water absorbs more heat than any other substance, pound for pound. It will absorb more heat than gold or iron, and it loses its heat more slowly than most substances. When the streams leave their source they are very deep, and gradually widen out and become shallower, so that the Gulf Stream in mid Atlantic is probably four hundred miles wide, and has a temperature of from 10 to 20 degrees higher than the surrounding ocean."

"How fast do the streams move?"

"From two to five miles per hour."

"So the stream in the Atlantic must take about forty days to cross?"

"Yes, approximately that."

They still followed the path, or rather one of the paths, for many of them merged into the main one, and it was evident that the island contained many species of animals, but their timid natures did not permit of a close approach. They saw many of the cow tribe, and numerous wild hogs, but the boys had no opportunities to try their weapons on any of them.

The feeling of fear was to a great extent dis-

pelled in the boys. Their previous experience had given them courage.

On the third day after their departure from home they estimated that they must be fully fifty miles from the sea. Although they doubtless had reached a considerable altitude, the sea was not visible in either direction. They were probably from ten to fifteen miles from the river.

To the north of them in the distance the landscape had the appearance of slightly rolling hills and timber. To the southward appeared a faint outline of mountains, and to the west was a rolling plain interspersed by timber.

"How high up do you suppose we are?" asked Harry.

"That is a difficult matter to judge in the absence of proper instruments; to make a guess, I should say anywhere from 400 to 600 feet above sea level," was the Professor's reply.

"Isn't there any way we could determine that?"

"It would be impossible to make any calculations without the proper instruments."

"How is the observation as to the height made?"

"The altitude is determined by means of a mercury column."

"What do you mean by a mercury column?"

"A column of mercury a little over 29 inches high weighs the same as a column of air about forty miles high; 29 inches of mercury weighs just as much as a column of water 32 feet high. Remember these three things: If we have three pipes, each, say, one inch in diameter, one pipe 29 inches high, one pipe 32 feet high, and the other

pipe 40 miles high, and filled with mercury, water and air, respectively, each will weigh fourteen and three-quarter pounds. That represents the air pressure on every square inch of surface."

"But I don't see how that will enable us to tell the altitude, as you call it."

"Well, then, suppose you take one-half of the water out of the tube, how much will the water remaining in it weigh?"

"Why, just half as much as when it is full."

"Exactly so. On the same principle, then, if, in measuring the air column, you shorten that column, its weight will be in the proportion shortened, will it not?"

"What is the instrument called which determines altitude?"

"The barometer."

"I thought the mercury was used to indicate the temperature?"

"So it does. But in that case the expansive quality of the metal is used. Heat expands nearly all known substances. Ice, on the other hand, contracts by the application of heat. Mercury expands more than any other metal, and moreover it is in a liquid form and is therefore suitable for determining temperature and altitude."

CHAPTER X

SIGNS OF SAVAGE NEIGHBORS

THE landscape now became more rolling and uneven, and they were obliged to cross several hills which ranged east and west, and finally reached a small stream flowing to the east. The river valley was rather narrow, and at one side or the other the stream was bounded by rocky hills, which were rough and jagged in many places.

In making their observations they discovered that the stream was flowing from the northwest. The South River, as they called the larger one, which they had left two days before, flowed from the southwest, and when they sat down to rest the Professor said:

"What do you infer from the direction of these two streams, coming as they do from the northwest and from the southwest? We ought to be able to judge somewhat of the character of the country by the direction and the flow of streams."

"Do you think, Professor, that these streams will tell us what kind of country there is to the west of us?"

"We can learn of the character of the land beyond, short of an actual investigation, only by making use of such knowledge as we may possess of other streams that go through countries which we do know. We might be able to tell with reasonable certainty whether the water of the river is

supplied by springs or whether it is surface drainage."

"How does the water tell you that?"

"By ascertaining whether the water is hard or soft. If it is hard, it is safe to infer that the river is formed of springs. If it is soft, it is more than probable that it is supplied by surface drainage."

"Do you think the water of this stream is hard?"

"Suppose, Harry, you try it with some of the soap."

The soap test was applied, and Harry said: "It acts as though the water was pretty soft."

"The water at the Cataract is soft, too. I wonder whether this is not our river, after all."

"That is a good inference, and it is worth while to find out for a very good reason."

"And what is that?" asked George.

"Simply, because there is mineral in those rocks, and it may be a very convenient thing to raft down the ore to the Cataract house, as well as some of the fine timber we have seen all around here."

"When we go back, why not follow this stream down?" said George.

"What will we do with our boat on the South River?" asked Harry, who was always looking on the practical side of things.

The decision as to their course was left entirely to the boys to determine, and the Professor was finally appealed to for a decision. He said:

"It seems to me that the wisest course would be to continue our explorations up this stream as far and as long as we have the time and the inclina-

tion to put to this work, and then build a raft and float down the stream, which may or may not bring us to the Cataract. If it does land us there, it will be less than a half day's journey across to the South River where we left our boat, and by that means we shall have made a grand circuit through our domain."

"Capital," said both boys, in a breath. "But why not make the raft now?" was Harry's response.

"That might be done, but it may be a tiresome task to float it up the stream."

"What I wanted to know was, how we could find out about the character of the land to the west of us by the stream. We have been imagining what was to the east of us."

"Well, then, my inference from the stream is, that the land beyond, and through which this stream runs, is rather level, and that between this river and South River is rolling land, and that the South River has its origin in the mountains; whereas this stream has its source from comparatively level land."

"Why do you think so?"

"This water flows slowly, whereas the South River is a quickly moving stream, and thus shows a high source, for one thing; and in addition to that the South River is hard water."

"Well, I am glad we explored this river, because mountain travel would be pretty hard work."

"Of course, if this supposed island is inhabited we are more likely to find it out by going westwardly, rather than in the mountainous parts."

For three days more they journeyed up along the stream. At the rate they traveled, which did not exceed fifteen miles per day, they must have been fully sixty or seventy miles from the Cataract home.

They had been in the habit of following the crest of the hill nearest the river, as such a course gave them a better view of the country, and they went down to the valley only when water was needed, or when they took their meals or camped for the night.

Just before they were about to descend the hill on the third day referred to, and which was now the eighth day of their journey, they crossed a well-beaten path which led toward the river.

They remembered the other path from the South River, which had lured them away, and decided to follow this trail. When they landed on the lower level and were about fifty feet from the river bank, the Professor abruptly called attention to a spot not ten feet away. It was the unmistakable evidence of a fire, as portions of charred wood still remained.

The boys stood there almost petrified. Their worst fears were now realized. Somebody must be living on the island. The Professor was quiet, and remained intently observing the fire plot, and also critically viewing the surroundings.

"I do not know," he finally said, "whether this is an occasion for rejoicing or for caution."

"What shall we do?" said Harry.

"There is no reason for immediate alarm. We are certainly in no more danger now than a half

hour ago. A little knowledge, it is said, is a dangerous thing, and sometimes, as in this case, a little knowledge only appears to be dangerous."

"Do you think the fire was made by savages?"

"I suppose you both have read some of the famous detective stories in which wonderful deductions were drawn from the smallest things. Here is an opportunity for you to undertake a little detective work on your own account."

They examined the water's edge in the endeavor to get traces of footprints, if possible. There were no signs of bones or other objects which afforded the slightest clue. All the boys saw were relics of a small fire. Nothing more.

"What is your conclusion?" asked the Professor.

"I can make nothing out of it," said Harry. "Have you discovered anything?"

"I think they were savages, or at any rate not civilized men. Furthermore, there were only two or three at most."

"Why do you think so?"

"From several indications. One of the sticks we examined was used for starting the fire."

"We hadn't noticed that. But we also used sticks to start our fire, and we are not yet savages."

"Quite true; but this stick was used in a way peculiar to savages of the South Seas."

"How is that?"

The Professor picked up one of the wooden sticks. "This is the piece which gives me a clue. You will see it has a blunted charred end and the other end is smooth. You will also notice that

the middle of the stick has circumferential marks or creases."

"What does that indicate?"

"That they made their fire with this stick by holding one end against a block of wood, and rapidly revolving it by means of a bow-string. The mark in the middle of the stick clearly indicates this."

"But what makes you think there were only two or three?"

"The vegetation around the fire was not damaged, and it must have been at least a month since the fire was made."

"What makes you think that?"

"You will notice that grass has already grown up through many places where the fire must have been."

"What puzzles me is, what they made the fire for. There are no bones or other evidences of a feast here."

"Animals may have removed all such evidences since that time."

All doubts as to the human habitation on the island were now dispelled. They looked at each other with questioning eyes.

"Shall we go on or return?" was Harry's first question.

"For my part, I think the only thing we can do is to return," was George's response.

"Yes," said the Professor, "we are not yet in a position to meet any wandering tribes, and endeavor to establish friendly relations."

"Then hadn't we better build our raft and leave as soon as possible?" said Harry.

"We cannot do this any too soon."

It did not require any urging to stimulate the boys. They were now brought face to face with a disquieting problem. It was not what they knew, but what they didn't know, that brought anxiety. With their combined energy it did not take long to select and prepare a number of tree limbs, and they were facilitated in this by the dry limbs of a fallen tree near at hand.

"If you will examine some of the broken limbs you will see where our visitors got their fuel. You will also notice that they broke the limbs, but did not cut them with any tool."

To the boys this was conclusive proof that when the time came they would have to deal with a race of ignorant, if not savage, people, and it was now their aim to go home and make the necessary preparations for the time when they must meet them. The boys knew, as well as the Professor, that sooner or later they would be thrown into contact with them.

Before noon of the ninth day they were well on their way down the stream, which flowed lazily along, and as they proceeded the hills on both sides grew lower, and the surface of the surrounding country less rough, but the trees grew thicker. Before the end of the day they had forests on both sides of the stream, and they found that the course the stream took was eastwardly with a southern trend.

"It can't be possible that this stream flows into the South River?" said Harry.

"I don't think so," said the Professor; "we should have crossed the stream on our way up, and I do not remember any stream as large as this anywhere on our route up along South River."

They made fully twenty miles the first day, and the second day brought them to the eastern edge of the forest, so that they had covered at least forty miles. The flow of the stream now appeared to be probably about two miles per hour, and they hoped that the forest from which they emerged was the eastern limit of the wood which they had entered on their former journey.

Toward night of the fourth day they again entered a very dense wood, where it was agreed they would camp for the night, so they could pass through the forest during the following day. Here George was successful in shooting his first animal, a hare, and they made a good meal before retiring.

Earlier than usual the next morning they were astir, and after a hasty breakfast, were again under way. Before noon they were relieved to find themselves at the eastern edge of the forest, and the stream now turned to the northeast.

"Stop," said the Professor, peering over the side of the raft. "Let us examine that." Harry and George both dug their poles into the bed of the stream and brought the raft to a sudden stop.

"Push it closer in to this side," said the Professor. "Do you see the footprints on the shore?"

The eyes of the boys opened in astonishment.

George was the first to recover himself, and burst into laughter.

"It seems we are afraid of our own shadows."

Harry did not see any cause for laughter, but the amused smile of the Professor was sufficient to reassure him.

"Here is where we crossed the river when we first went into the forest; don't you remember, Harry?"

"So we are really on the river which flows to the Cataract?" said Harry.

"We have not yet proven this to be the case, but it looks like it."

It did prove to be the case, however, and shortly after noon they saw Observation Hill in the distance, and within an hour were in sight of their home.

"What has become of our flag? It isn't there."

"I would like to know what that is, moving down at the house?" said Harry, as he dug his pole into the stream and brought the raft to a standstill.

"It looks as though we have company," said the Professor, "and it is time to proceed cautiously."

It was now Harry's turn to burst out in laughter. "Turn about is fair play," he said, as the Professor and George looked at Harry intently, to discover the cause of his mirth.

"Cows! look at the herd!" and Harry dug down his pole and gave a vigorous push to impel the raft forwardly.

As they neared the Cataract it was only too plain that their captives had induced others of their friends to take up quarters with them, and

when they finally disembarked and made their appearance over the cliff walls it was a signal for the herd to scamper down the river.

Their particular cow, however, and the calf, kept on feeding unconcernedly, and the calf, particularly, seemed to be pleased with their return. The herd, consisting of a bull, five cows and four calves, or younger animals, did not go far, and before many days passed they became familiar with the boys and returned to the quarters. They had learned the lesson that the animals could take care of themselves, so that there was not thereafter any more care or trouble from that quarter.

CHAPTER XI

THE FIGHT OF THE YAKS

It was, indeed, a pleasure to be home again, even though the absence was only for twelve days. Harry's first thought was for the sawmill, which had been undisturbed. George went immediately to Observation Hill to investigate the disappearance of the flag. He found neither flag nor pole.

When he reported this on his return it was a source of considerable speculation. There had been no storms of any consequence since their departure, so it could not be attributed to that cause.

At their consultation that evening it was decided immediately to put up their factory building, adjoining the sawmill, so that for some days they were engaged in cutting and rolling down to the river a quantity of logs which they could easily handle. These were floated down and finally cut up into boards for the sides, floors, and roof, and other trunks were cut for the joists, studding and sills, so that fully a week elapsed before they were ready to put up the building.

This was a structure fifteen by twenty feet in size, and was distant about fifty feet from their house, and to this factory they removed all their apparatus; and, at the suggestion of the Professor, they spent several hours each day in getting together the various ores, slate, clay, and other like

products in the near vicinity, so that they would at all times have the material to work with.

In addition to this they cut a quantity of a soft wood, not unlike the common pine, and they also secured samples of hard wood, particularly oak, and a kind of redwood. This, when cut up, was stacked up to dry for future use.

They then made a lean-to shelter for a furnace, as the Professor suggested that they should now try to work their mines, and also produce a quantity of iron and steel, for the reason that lack of firearms was a serious handicap to them.

"Do you mean that we can make guns?" asked George.

"Why not? We have made some things that are nearly as difficult and I see no reason why we cannot provide those articles as well."

You may be sure that this announcement was not vetoed by the boys.

"Our first step must be to make the tools—good cutting tools—for our purposes; and, George, while Harry is preparing the tools and tempering them, you may beat out several more pans from the metal sheets we still have, as we are very much in need of cooking utensils. Then we also need a stove which will be more convenient than the one we have."

In a few days more the tools were completed, and George had made up, out of the firebrick, a really serviceable stove for cooking purposes. When Harry announced the completion of the tools he called the Professor into conference and showed his products with a great deal of pride.

"See, I have made a few sharp cutting chisels, as you directed, which I know will cut iron, but I do not yet see how I can use them."

"Then why not make a lathe to use them in?"

"But to make a lathe requires so many things, and I don't know where to begin."

"Well, in order to make a lathe, requires a planer, a sharper, a drill, and a milling machine. It does seem to be a pretty hard job, to say the least," said the Professor. "But how do you suppose the first lathe was made?"

"We must make something that makes something to make the lathe with, I suppose."

"That is a pretty good answer, because it states the conditions exactly."

"What is the most important thing in a lathe?"

"First, a revolving mandrel or spindle; and second, a straight frame or body, to carry the cutting tool."

"I think some of our oak pieces would do for the frame."

Two of the heaviest and finest pieces of the oak were then selected for the frame. These were very rough, so that it was necessary to devise means for dressing them down true.

"I must have a plane," said Harry.

"While you are at it, make two, one of them 14 inches long and the other 28 inches long."

"Why are two needed?"

"The short one is the jack-plane, and can be used for taking off the rough saw cut; the other is the fore or finishing plane, and, on account of its

length, is what you need for finishing off and trueing the bars of the frame." *

The two pieces of oak selected were four by six inches in dimension, and each six feet long. These were placed parallel with each other, four inches apart, and mounted on heavy legs at each end.

"Now, Harry, do you think you could forge out a shaft, say, 18 inches long and an inch or more in diameter?"

After some work he succeeded, but as it was still rough and uneven, both boys had to use the grindstone to true it up to the best possible condition. When this was completed to their satisfaction the Professor suggested that one end of the shaft should have a head or a disk attached. Here was, indeed, a problem for Harry. He pondered over the matter for a long time, and then took the problem to the Professor.

"Don't you think you can weld it on? You have done some pretty good work in that line."

"If I weld it on it will destroy all our work in trueing up the shaft."

"That is so," said the Professor, "so I suppose the only other remedy now is to braze it on."

"How is that done, and have we the materials for it?"

"If you will look in the storeroom you will find some copper there that we took from one of our mines nearly two months ago. And while you are

---

* *Carpentry for Boys, New York Book Company,* goes fully into the structure and use of tools.

there bring along one of the lumps of fine salt that we found."

"Do you mean the kind you wouldn't let us use?"

"Yes."

"Well, wasn't that salt?"

"No, it is borax."

"What is that for?"

"To use as a flux."

"I don't understand why a flux must be used."

"So as to facilitate the unity of the copper with the steel."

"Do you intend to unite copper and steel?"

"Yes, that is what the brazing process means. Unfortunately, we are not yet in a position where we can recover any of the zinc from the blende ore I spoke to you about some weeks ago, and of which we have some samples. As it is, we must use the pure copper, but if we had some zinc we could make a hard solder which would melt at a much lower temperature than copper, and thus greatly aid us."

"How is the hard solder made?"

"It is composed of nearly equal parts of copper and zinc. Brass is a compound of two parts copper and one part zinc, and is harder than zinc, and also works better than copper."

"Come out and see the fun, Harry," cried George, as he appeared at the factory. Harry was out in an instant. Two of the cows were engaged in a fierce fight on the upper plateau or elevated portion of ground, and close to the low cliff that bounded the field below the cataract. Their method of fighting was not unlike that followed by

the genuine bovine species, with the locked horns, surging back and forth in a most vigorous manner. After this had continued for some time one of the animals, being on the upper or rising side of the cliff, bore down upon the other with such velocity as completely to overturn the one lower down, and before it could regain its feet was swept down over the cliff, which at this point was fully fifteen feet high.

The animal lay there without moving, for a time, completely stunned. Without waiting the boys rushed down, to find that all of the animal's legs had been broken. The Professor soon followed, and seeing the condition of the animal advised that it be killed, a task which he undertook to perform.

Here was the opportunity for which the boys long had waited, and it came to them unexpectedly. They set to work skinning the animal, and in quartering the carcass, every part of which was preserved. A large portion was put into a strong brine and turned into corned beef, and for some days they had the best steak and roast imaginable, considering that this was the first real beef they had tasted for months.

"What shall we do with the hide? If we could only tan it."

"That is just what we must do," said the Professor.

"Tell us what to do," said George, all excitement, at the announcement.

"Well, George, I'll commission you to get some of that rock which we saw sticking from the hill near the spring."

He was off in an instant, and finally brought several pieces.

"This will not do at all. It must be limestone, because we must make lime."

Both boys now took a hand in the search for the right kind of stone.

"You can tell limestone from the other kinds, particularly because it has no sand in its composition, and furthermore, it is a rock with definite lines of cleavage. Notice that rock. It is a sandstone, and is also darker than the limestone that we must have."

With these suggestions they finally succeeded in getting a fine quality of stone.

"Now let us make a lime kiln. Here is where our furnace will come in to good purpose. Down at the bottom make an arch of the firebrick, so there will be plenty of openings through the arch. Now break up the stone, so the pieces are not too large, and put them into the furnace, and build up the stone so as to make sufficient spaces between the stones."

Several hours of this work completed the job, and charcoal was used to start the fire, and afterwards wood was used to supply the heat.

"We now have a fairly good-sized job before us," said the Professor, "because we must keep up the burning for at least three days and three nights, so we will work in shifts during the night, or we will ruin the product. Fire must be supplied at intervals right along until we get lime."

"Why does it take so long to make the lime?"

"The object of the fire is to drive the car-

bonic acid out of the stone, and when that is completed it is fully calcined, as it is called. The product is known as calcium for this reason."

"It seems to me that we have a pretty good lot of lime for one hide."

"It does seem so; but we have uses for the part we do not need in the tanning process."

"And what is that, Professor?"

"Don't you think we could use plaster of Paris, and also cement, if we had it?"

"So we could. But how is plaster of Paris made out of the lime?"

"If we roast the lime at a low heat and grind it we have plaster of Paris, which is technically called Carbonate of Calcium."

"But that isn't cement, is it? I know it gets hard."

"No; in order to make the hard-setting cement, the lime is mixed with river mud, which contains the finest particles of sand, and this is then roasted or calcined."

At the end of three days the fire was allowed to die out and the furnace cooled down. When they opened the kiln they were delighted to find a beautiful quality of lime, a sample of which was taken by the Professor and water poured over it. Immediately the water began to smoke, and the rock finally broke apart.

"You know what this is called?"

"Yes, that is slaking the lime. Wouldn't that be the thing to plaster our house with?"

"I presume we shall get to that by and by."

"And now for the hide. What shall we put it in?"

"Probably the most convenient thing will be to dig a hole and resort to our well-known way of using clay for a lining."

This was speedily done, a quantity of lime was duly slaked, and the hide submerged in the lime water thus made.

"What does the lime do to the hide?"

"The object of the lime is to remove the hair."

"How long will it take to do this?"

"That is a difficult matter to determine," said the Professor. "We may not be able to remove the hair at all by the present process and we may have to do it all over again."

"Why is it so difficult to tell about it now?"

"In the treatment of leather modern science and invention has found a means to hasten every step in the process, but the removing of the hair is still as slow a process as it was three thousand years ago. It is only within the past few years that the discovery was made which accounted for this. It appears that there is a tiny bacteria, which is germinated by the lime acting on the tissues of the hide, and the peculiar function of this germ is to burrow down to the roots of the hairs and loosen them. The natural action of lime is to tighten the hair more firmly, were it not for the aid of the tiny insect."

The pelt was left in the brine for several weeks, and when removed it was found that the hairs were still tightly adhering.

"Too bad," said Harry. "I hoped we could get

a good sample of leather, because it would come in very handy for shoes."

"We must not despair. Let us take out the hide and put it into another solution, and be sure to preserve the lime water that it has been soaking in."

"Of what use is that?"

"The singular thing is that lime water in which the hides has soaked, will in time breed the bacteria necessary. In fact, the lime water which has once removed hair is the best adapted for dehairing, so we may yet be able to get the hair off."

The Professor's statement was really found to be the fact for, when later on, the hide was put back into the original lime solution, there was evidence within a week thereafter that the hair was coming out.

"When we take out the pelt be sure to save the hair."

"Of what earthly use can the hair be to us?"

"It will make fairly good blankets, if we only had enough of it."

"Blankets out of that short hair?"

"Yes, felt blankets; and we can make them without having to depend upon a weaving loom."

CHAPTER XII

HARNESSING THE CATARACT

"WELL, Harry," said the Professor, one day, "how is the lathe coming on?"

"I have made a very fine bed, as you directed, and have also built on one end a framework to hold the mandrel, and a sliding tail stock which I can adjust at any point, and hold it securely."

"That is good. But I see you haven't brazed on the disk yet."

"No, but I am ready to do it with your assistance."

"Can you find any means to hold the disk temporarily to the end of the mandrel? If so, we are ready to make a kind of blower to supply a large quantity of air to the fuel."

"Why do we need so much air?"

"Because the heat we are able to make will depend on the amount of air we can supply to the fuel. Carbon fuel requires at least two parts of oxygen to one part of carbon, and as our fuel is in the solid form we shall need at least four times as much air as we can get by a natural draft, such as we have been depending on in our previous work."

"Couldn't we make a bellows out of the piece of bearskin that is left?"

"Capital idea. Get it at once, and while we have the power, we might as well hitch up the handles

of the blower to our water-wheel shaft and let it do the work for us."

"So we can."

George undertook at once to prepare the bearskin, which was cut into an oval or elongated shape, and tacked to the edges of a pair of pear-shaped boards. One of the narrow edges of the boards was then secured to a square block of wood which had a hole through it, and the narrow end of the other board was secured to the block by means of the leather, so as to form a hinge, and by that means the wide end of one of the boards could be moved to and from the other board, and the bearskin, which connected the edges of the two boards, served as the collapsible part of the bellows.

"We haven't completed the bellows yet," said the Professor. "We have a hole through the block for the air to get out, but we have no provision for the air to get in."

"It will be an easy matter to bore a hole in one of the boards."

George did so, and the Professor then requested him to move the hinged end of the board to and fro.

"This does not force out air. What is the matter with it?"

"I notice you have no valve in it."

"I had forgotten that. But how is the valve attached?"

"It must be made to open inwardly. A piece of the bearskin will do, one end of which can be tacked to the inside of the board, so the piece

will cover the hole. Now, when you open the bellows out, the air will go in through the hole, and when you press the boards together the air, in trying to get out of the hole, will close the valve and thus find itself imprisoned. But you should put in another valve at the block, or nozzle, as the block with the hole in it really is, and that valve must open outwardly."

This bellows was finally adjusted and attached to the water-wheel shaft so that it kept up a continual pumping motion. A wooden tube was then run from the nozzle of the bellows to the space below the fire-box of the furnace. The furnace was simply a squarely built structure of firebrick, with broken up pieces of firebrick in the bottom on which the coke was laid, and below which the end of the air nozzle was placed.

When the fuel was ignited it did not take long to bring the coke up to a white heat. In the meantime Harry had been able, with his cold chisels, to cut out grooves near the end of the mandrel, and had succeeded in forming four fingers from one side of the disk, so that by dint of hard work the fingers were finally turned inwardly and served to hold the end of the mandrel by being driven into the grooves made in the end of the mandrel.

"Are you all ready? Then bury the disk and end of the mandrel in the white coke, and when the mandrel and disk are at a white heat also put plenty of borax around the place where the disk is to be joined to the mandrel, and then drop small

pellets of the brass on. As soon as the brass melts the mandrel must be taken out."

The instructions were explicitly followed out, and it was with a great deal of satisfaction that they found the disk firmly attached to the mandrel, as the fluxed copper had caused it to flow between the united or joined edges of the metal pieces, and on cooling they became as solid and firm as though made of one piece.

"What an immense amount of hair that animal had!" said George, as he returned from one of his hair scraping jobs.

"The hair of the yak is very thick on the animal and it is also fine and silky—much finer than the hair of the common cow."

"Why did you have the long hair which grew under the body of the yak cut off before we put the hide in the lime?"

"For the reason that in making felt those hairs would be too long."

"I thought the longer the hairs the better the cloth would be."

"So it would if the cloth was woven; but you will remember I said that we would make the felt without weaving it. By the way, I see that the soles of your shoes are almost worn out. Let me suggest a protection for your feet. Wash some of the hair to get it free from lime and distribute a coating of the hair in the bottom of the shoe, and then cover the layer with a piece of cloth. Wear the shoes in that way for a few days and then take out the hair."

There was no inclination on the part of George

to question the motive of the Professor's sudden interest in his shoes. He tried the experiment, then forgot the incident.

It had long been the desire of the boys to try their luck at fishing. They had every reason to believe that their river had plenty of fish, but without fishhooks and lines they would stand a poor chance of succeeding. Now that they had an abundance of strong cord and were making a good quality of steel, Harry undertook, in a quiet way, and unknown to the Professor, to construct several hooks in which he succeeded so admirably that the thought came to him to try to make some coarse needles.

This was one of the most difficult mechanical feats he had thus far undertaken, for the reason that there is nothing so trying, even to a good artisan, as to anneal and temper the small, wire-like pieces of metal which are necessary in the making of needles. He had no difficulty in annealing the wire, which was laboriously forged out. He then made a small hole for the eye, but the trouble was to temper it so as to bring it to its original state of hardness.

Although Harry did not know it, the difficulty was, that when he heated up the wire, in trying to temper it, the body would be hard, and the point soft. At last he was compelled to go to the Professor with a sample.

"I see you have a good needle, and I commend you for the ingenuity and patience you have shown, but the point is too soft."

"That is just the trouble. I have tried a good many and with the same results."

"Did you sharpen it and then anneal and temper it afterwards?"

"Yes."

"That is where you made your mistake. You should have tempered it before you pointed it. If you will remember, when you had the saw teeth cut, you tempered it before you ground down the teeth to a cutting edge."

"What difference does it make, by doing it before or afterwards?"

"When it is pointed before you temper, the small point cools down by its own absorption of cool air, or by a gradual process; but the other part of the needle is suddenly chilled, which is the necessary thing to do, so that while the body of the needle is tempered, the point is not."

With this lesson you may be sure Harry had no further trouble.

But Harry had something else to learn when he tried to make the fishhook. That had to be tempered, too, or it would bend out straight when a good-sized fish was caught, and he finally discovered that he had to bend the hook, then temper it and afterwards make the point by grinding it down.

The boys were very eager to try their hand at fishing, so they proposed a fishing jaunt for the day, to celebrate their new accomplishment.

"I'll get the bait," said George, as he hunted up a digging tool.

They selected a cove in the river above the

cataract, and with three fishing equipments were very happy in the prospects of the day's sport.

In an incredible short space of time the Professor landed the first fish, a beautiful specimen, about ten inches long.

"A perch," said George, in delight. "What a beauty it is!"

After that the boys began to haul in one after the other, and they had a good variety, too, some bass, and also whitefish. It was a problem to know just which fish would be the most acceptable for the first meal. The boys settled the matter by selecting the Professor's first catch, but you may be sure that one fish was not enough for that meal.

The following day the Professor inquired of George as to the condition of the hair soles which he had been advised to wear.

"I had forgotten about it," was the answer. George took off his shoes and removed the felt soles. They were matted together so as to form two pads that looked like cloth. The boys were astonished at this.

"Why, it doesn't seem to come apart, at all. It is just like a piece of cloth."

"You have been making several pieces of felt goods," said the Professor. "I think we ought to make some felt products with the hair we have, and our next step should be to provide a considerable quantity of hair for making up a lot of the goods."

"But it will be a pretty hard thing to make our felt goods by walking it into shape."

"Then we shall have to make something that is better than the feet for this purpose."

"We are ready to do it."

"Get several pieces of our ramie cloth, each, say, three feet square, for our first experiment. Lay one of them down on a level place. Now, George, bring the hair, and distribute it carefully and evenly over the cloth."

This was soon done to the satisfaction of the Professor.

"The next step now is to moisten the other cloth, and carefully spread it over the hair-covered cloth. There, that will answer. Now, fasten the edges of the two cloths together so that the hair cannot possibly come out. I think that will do. Get some small thin sticks and beat the moistened cloth top, moving the sticks around at all angles on the cloth."

The cloth was thus beaten for a considerable time, and occasionally a small quantity of water was sprinkled on. When it had thus been beaten the edges of the two cloths were separated, and behold, they took out a piece of felt three feet square, which, while it was very loose in its texture, was nevertheless of sufficient strength to hold together.

"It doesn't look to me as though this will be of much use to us. It isn't nearly so firm as George's shoe pads."

"Well, we haven't done all to it that George did with his samples."

"And what was that?' '

"Why, George fulled his felt."

"And what is fulling?"

"It is the term used to designate the process which George was engaged in when he was tramping the hair for several days."

"So we haven't yet finished making the felt?"

"No, in practice there are several steps necessary, but for our purposes we can get along pretty well simply by fulling our goods."

"What is the best way to do this?"

"First prepare a lot of soapy water, using a vessel long enough to put the felt in. The felt is put between the ramie cloths that we beat it in. Now, roll it up, rather loosely, and put it in the suds."

Sets of strings were then tied around the roll thus made and after soaking a while, the roll was taken out and beaten, all around the roll, and also on the ends of the roll, and then put back into the suds. This was repeated at least a dozen times, when the Professor announced that the operation was finished.

"What has become of it? It isn't half as large as it was, and it is not nearly as thick as it was, either."

"But isn't it stronger and the fibers closer together? You see the felt cloth does not have a tendency to fall apart. The individual hairs are now fully incorporated and entangled with each other, and will remain so."

One evening, while engaged in their usual conversations, the boys wanted to know if they could not determine in what portion of the globe they were. They knew they were in the Pacific Ocean,

west of South America, and south of the equator. The only thing that gave any indication as to possible latitude was the weather. To the Professor, of course, the position of the sun was the best criterion.

It was about the 20th of March, which, for the southern hemisphere, is the same as September 20, north of the equator, considered from a weather standpoint. There had been no cold days, and judging from the weather, they concluded that they were nearer the equator than 41 degrees south latitude. New York is about 41 degrees north latitude.

"We can figure out our latitude with very little trouble, with a few simple instruments," said the Professor, "because we have a definite line to calculate from. But it is not so with the longitude. Longitudinal lines are calculated from an arbitrary point selected for the purpose, like Greenwich, England."

"What is the positive line we have to calculate latitude from?"

"The equator."

"Why are all measurements made by degrees?"

"A degree is not a measure. It is merely a term used to designate an angle, an interval, a position, or a point."

"Then when the expression 45 degrees south is used it does not mean that it is so many miles from the equator?"

"Not by any means. It simply refers to an angle which extends from the center of the earth,

or, for instance, from the center of a disk. Do you understand why this is so?"

"Not exactly."

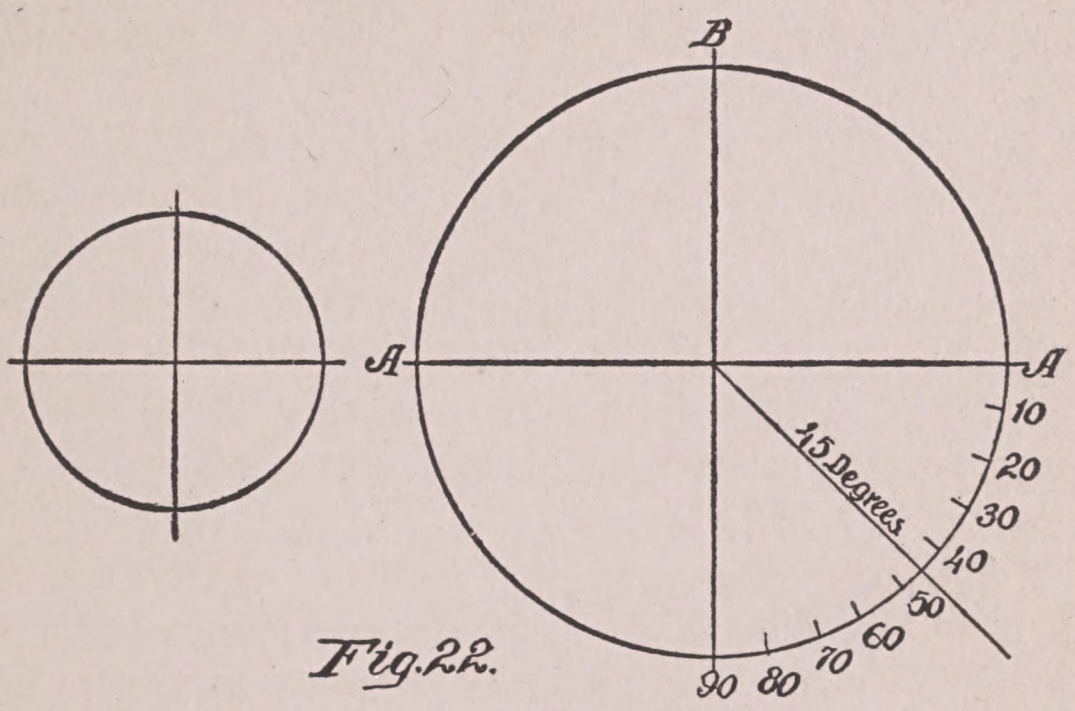


Fig. 22.

WHAT DEGREES MEAN

"Suppose we have two disks, one of them two feet, and the other one foot in diameter. Now let us draw a horizontal line (A) and also a vertical line (B) through the middle of each disk, which we will call the equator and the poles, respectively. You know, of course, that each circle, great or small, is divided into 360 degrees, so that south of the equator we have 180 degrees, or 90 degrees on each side of the line of the poles. Halfway between the vertical or pole line and the equator, would be 45 degrees on both disks; but you will find that the distance from the equator to the 45 degree line at the margin of the large disk is twice as long as the same line on the small disk."

"I see it now. But is the globe divided up into the same number of degrees east and west?"

"Precisely the same, so that from Greenwich there are 180 degrees east and 180 degrees west. The line halfway around from Greenwich passes through Behring Sea, to the west of Alaska, and down along the east coast to New Zealand."

"Then how can the position of a ship be found east and west of Greenwich?"

"It is a question of time. Suppose I set my watch at Greenwich, and it keeps accurate time, I will then have with me, wherever I go, Greenwich time."

"And that will then tell how many miles you are east or west of Greenwich?"

"No; it will tell the degrees, because the degrees of longitude are not the same length at the equator as they are nearer the poles. At the equator the length made by one degree of angle is about 69 miles. At 44 degrees it is only three-fourths of that, and at 60 degrees it is only half the distance that it is at the equator. So, you see, degree does not mean measurement."

"If that is the case how will the time tell us how far we are in miles?"

"Every fifteen degrees east or west of Greenwich means an hour earlier or later. Suppose my Greenwich time indicates three o'clock. If, at the same time, the local watch is at seven o'clock, we are four hours away from Greenwich; and four times 15 would be 60 degrees. At the equator, by that reckoning, we would be 69 x 60 miles from

the longitudinal line at Greenwich, which would be 4,140 miles."

"What is meant by the words 'latitude' and 'longitude'?"

"The earth is about 26 miles greater in diameter through the equator than through the poles, hence the word 'long,' or longitude, is used to designate the length east and west, and latitude the breadth, or north and south. For the purpose of explaining and calculating latitude we have no time for it to-night in the absence of a few instruments which we must have for the purpose."

CHAPTER XIII

MAKING EXPLOSIVES

"I HAVE all along had a curiosity to know why you have been making a sort of refuse heap of the pieces of meat and the stable manure, and what interested me most was to see you take some of the lime water out the other day and carefully pour over the mass," said George, one day as the Professor was returning from one of his trips.

"I suppose I shall have to satisfy your curiosity. You are wonderfully alive in watching things. Well, I am trying to make saltpeter."

"Saltpeter, out of all that mass of stuff? Why, at home we used saltpeter with the salt in curing meat."

"Yes, and it is also used for medicine, and it doesn't taste badly, either."

"I never knew it was used as medicine, too."

"It is niter; you probably know how that tastes, and it is like saltpeter."

"Well, I don't think I shall care to taste the stuff again, now that I know how it is made."

"While the elements from which it is made do not seem to be very palatable, still, the resultant product is absolutely pure."

"But what are we going to use saltpeter for?"

"I thought you said the other day that we ought to have some guns, and a gun is of no use unless we have gunpowder."

"So saltpeter is used in making the powder? And what else is necessary?"

"Sulphur and charcoal."

"I know we have plenty of charcoal, and I understood you to say that there was sulphur in the copper ore which we brought from the hills.

"But I do not understand why uniting those three things should cause an explosion."

"The powder, or, in reality, any explosive, is merely a fuel, and what a fuel needs is a sufficient amount of oxygen to support combustion, and enough heat applied to set it burning. When the powder is made it is finely ground up and all the elements intimately mixed up together, so that heat applied to it rapidly evolves a gas, while it explodes, and the expansion of the gas is sufficient to drive out a bullet or to tear rocks to pieces."

"But when a boiler explodes it isn't the fuel in the water or steam that burns."

"That is a good observation. You have deftly caught me up on my definition of an explosion. The heat is really the initial cause of the explosion, but not the immediate cause. When water is turned into steam it expands 1,700 times, and as the heat of the furnace increases the amount of steam beyond the capacity of the boiler the explosion follows."

Harry had now progressed far enough with his lathe so that he was ready to put it together, and the Professor suggested that he should grind out a few notches in the rim of the disk which he had brazed on the mandrel.

"Why do we need the notches?"

"As you have so far not yet made a drill, and you would find it difficult to use one even if you had it to drill steel, the notches will be necessary to enable you to hold an article securely to the disk, so that it will not turn independently of the disk."

"I quite understand the reason now."

It required the work of several days before the crude lathe was finally set up, and the small pulley on the mandrel connected up by a belt with the pulley on the water-wheel shaft.

While Harry was busily engaged on his lathe the Professor and George took up the work of making a wagon, and while so engaged George broke out with this observation:

"Why can't we use our yaks as horses?"

"That is just what they are exclusively used for in Thibet. The herd we have would be just suited if we can train them to the yoke."

"Well, I have seen oxen trained many times, and I would like to try them, anyway."

"As we must have our wagon at all events, let us continue the work and devote an hour or so each day to the task of training our stock to the yoke."

"And, as usual, before we do anything, we must do something else, as Harry said, to carry out the main object. I mean we must make a pair of yokes."

"Why not one yoke? It might be well to try one at a time. You see what habit or custom does. You have never seen an oxen driven singly,

so you have the idea that two are absolutely necessary. It is the custom in many of the eastern countries to drive the oxen singly."

"I suppose the reason that Americans always drive a pair of oxen, and never use them singly, is, that we always want to do the thing by wholesale."

"There is a good deal of truth in that, but there is no doubt the far easterners use only a single animal because forced to do so on account of economy."

Their first experiment was with their original captive, which was indeed a very tractive animal, but the boys had a lot of fun with the half-grown bullocks, which readily yielded to their training, and they soon had a pair broken which from that time forward was in almost daily use, carrying out the extensive work in which they were engaged.

The weather up to this time had been very pleasant, with only occasional rains. Nevertheless, it was thought advisable to make preparations for what might be termed winter months, not that it was liable to grow cold, but to carry them through the season when they could not depend on growing crops.

The Professor observed one day: "It is not at all likely that we shall have freezing weather, but there may be a season, such as is known on the southern Pacific coast of the United States, where vegetation does not grow at all, spontaneously, during the dry season, and that may be the case here."

"What time of the year does the wet season come?"

"In California the wet season begins about November 15, and ends in April. In Arizona and New Mexico, the wet season begins in July."

Their wagon would be interesting to describe. They were not yet able to forge metal axles, so the entire vehicle was made of wood. The wheels comprised four thicknesses of boards, nailed together, with the boards overlapping each other crosswise; and through the center of each they had to chisel a hole for the axle. The tread of the wheel was cut around by the power saw. Each axle was of oak, and four inches square; one of the axles being fitted to turn on what is called a king bolt, and to this axle the tongue was fixed. The wheels were two feet in diameter, and were placed four feet apart on the axles. It was exceedingly clumsy in appearance, but it was very strong, and it would hold more than they could possibly load on the bed, which was seven feet long.

Now, let us see what they brought to their Cataract home. First, they gathered a quantity of the ramie, their earliest friend; then they did not neglect the wild flax, of which they made quite a stack. They dug up a large quantity of the wild potato, which they found growing at various places, and which had now matured, as well as the cassava, the latter of which had formed a part of their daily diet.

"Don't you think, Professor, it would be a good

thing to lay in a stock of medicines, among other things?" said George.

"Really, I don't know that we have any use for medicines," said the Professor. "It would not be a bad idea to gather chemicals, as we could use them advantageously."

Day after day they discovered new things, to the delight of George. One day he rushed up to the Professor with a half dozen quinces, which were then ripe and golden.

"Do you know the legend connected with that fruit?" said the Professor.

"No, what is it?"

"In mythology the name of the famous sisters was Hesperides, who assisted by the dragon Ladon, guarded the golden apples which Hera had received on her marriage with Zeus, the God. With the assistance of Atlas, another deity, the apples were stolen by Hercules, who killed the dragon. This took place, the legend says, in western Asia, and the apples were quinces which grew there."

"But look at this beautiful flower. I have often seen it before."

"Yes, that is a northern flower, although it originated in Persia and Syria. It is the hyacinth."

"That's it; I couldn't remember, but it seems to me that the ones I saw were blue, and this is nearly white."

"Hyacinths vary greatly in color, but the principal colors are white, purple and blue. In Holland, where they are extensively cultivated, more than two thousand distinct varieties have been

named. I have just picked up, and we may take with us some of this plant."

"What do we want with the common hydrangea specimen?"

"As you seem to think we should lay in a supply of medicine this is a fine thing to commence with. The root is a good tonic for the liver, and is known as sevenbark. It is grown extensively in Japan, and the leaves make what is called the Ama-tsja, or the 'tea of heaven.'"

"I suppose," said George laughing, "that we might take some of the geraniums with us, too?"

"Why not? The Turks use geranium oil for the purpose of adulterating the famous attar of roses, and the leaves and flowers are medicinally used as astringents. So many of our well-known and despised plants contain medicinal properties which are sold under strange names, the Mignonette, which makes a beautiful yellow dye, is sold under the name of reseda, or dyer's wood; the bark of the black alder (not the elder) produces a purgative medicine, and is also used for the treatment of skin diseases, is sold as Ramnus Catharticus; rhubarb, also used as a medicine, is sold as Rheum; black currants, the tea of which makes a most cooling drink for fever patients, the plant of which is found in almost every garden in the States, is neglected for this purpose, because as a medicine, under the name of Ribes Nigrum, it is more effective to the patient. Why, even the root of the red raspberry, used as an astringent, sounds better as a medicine under the name of Rubus."

"Well, isn't the elder the same as the alder you just spoke about?"

"No; it is an entirely different plant. The elder is the Sambucus Nigra of the drug store. Both the flowers and the roots are used to make a soothing and a healing ointment and also for purgative purposes, and the wine from the berries is the chief adulterant for cheap port wines. In this particular I am inclined to think that adulterating it in that way is a good thing."

"From what you have said about all the plants and flowers, I do not think I shall again despise any of the familiar plants. They all seem to be our friends."

"Isn't that so with almost everything if we know how to treat them? There is good in all things if we only knew how to use them."

The quinces were a welcome addition; they gathered nuts of various kinds, but what delighted George most was the supply of Brazil nuts that they found on all sides, and in many places the ground beneath the trees was covered.

"I think Harry would enjoy the trip for the nuts," said the Professor, "so you had better make the trip to-morrow, as I have some particular work to attend to."

The next day the boys started early for the nutting expedition, and made their way toward the forest, following, so far as the hills would permit them to do so, the route which they had taken on their first trip to the forest. Before reaching the forest, however, they found so many nuts, some varieties of which were entirely new to them,

that before noon they had collected nearly a load and stored them in the wagon.

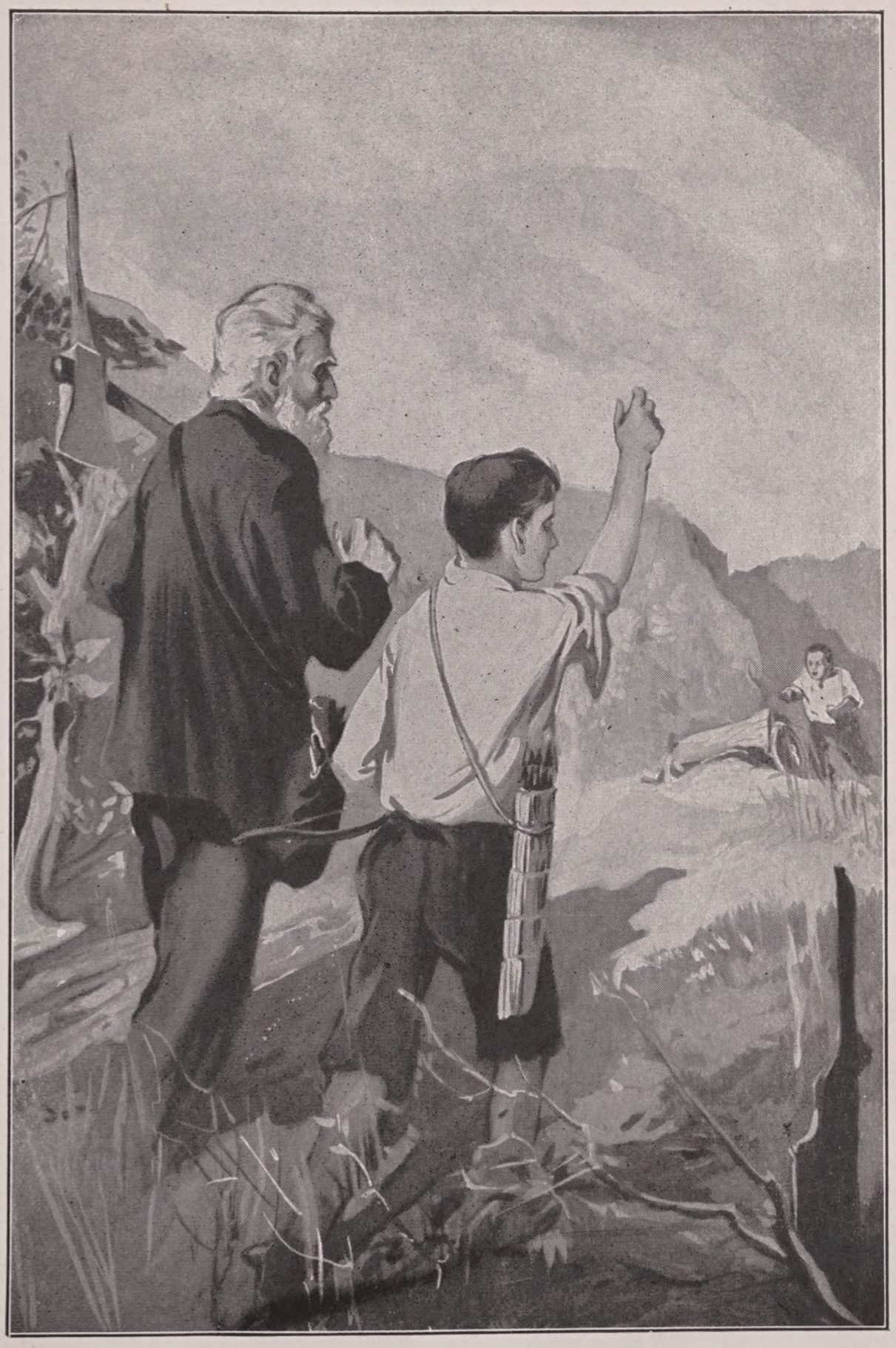
"It would delight the Professor if we brought home some odd specimens of the rock and ores which we saw coming up," said Harry.

"So it would," said George; suppose we put in the afternoon on specimens of that kind?"

The animals were tethered, so they could feed and the boys began their investigations in the hills. They generally managed to keep together, but sometimes, as interesting specimens would lure them on, they would become temporarily separated.

On one of these occasions Harry turned around to call George's attention to some particular sample, but he was not to be seen. He again called, but received no answer, and then made the peculiar sound or call so common to boys, which is usually a high-pitched "E-oh," over and over again. Thoroughly frightened, he now ran back and forth, going first to the wagon and back again, but there was not the slightest trace of him. The soil was too hard to make any indentations, which would afford a trace. He returned to the spot where they had separated.

From that point he radiated out in all directions, but it seemed that the earth had swallowed up his companion. The search was kept up for at least a half hour. They were fully three miles from the Cataract house, and Harry's first impulse was to drive the team down and get the Professor. Then he recollected that they traveled too slow



"Before reaching home they saw George coming toward them in great excitement"

[See page 200]

for the purpose, and without waiting he started on a run for home.

When he reached there he was surprised to find the Professor absent. He called over and over again without eliciting any response. He found the doors all carefully closed, and every evidence that the Professor's absence was premeditated. Where had he gone, and what was his reason for wanting the boys to go alone that day?

There was no time for him to make any further search, so he took up his weary march back to the team, in the hope that George might have returned in the meantime. He now regretted that he had not left some note or other information at the wagon so that George would not be alarmed in case of his return.

He had gone fully a mile toward the location of the wagon, when he was suddenly startled on hearing a terrific explosion. The shock was so great that he was unable to move another step. Not five hundred feet away, to his left he saw a cloud of dust and smoke. He debated with himself whether to go forward and investigate or to flee, but courage prevailed, and he made his way toward the smoke as cautiously as possible.

There, going leisurely up to the scene of the explosion, was the Professor who, after Harry had recovered his senses, did not heed the voice of Harry, and failed to notice his presence until Harry was close to his heels. It was the turn of the Professor to be startled, as he saw Harry, hatless, covered with perspiration, and almost speechless with the excitement.

"George is lost; he wandered away somewhere, when we were separated, and I have tried to find him, but all my searching was useless."

"When did that happen, and where?"

"Up toward the forest, over two hours ago."

"And where have you been all this time?"

"Hunting him, and then I went home to get you."

"Do you know the way? Don't let us waste a moment. Lead the way quickly."

In a half hour they reached the scene of their adventure and Harry pointed out that the wagon was located close to the large tree on the hill beyond.

Within ten minutes they reached the spot, only to discover that the wagon and team had disappeared. Here was another calamity. You may be sure that the discovery was not a pleasant sensation. The wagon, though heavily laden, did not make much of a track in the hard ground, but there was sufficient evidence to follow it by carefully noting the crushed vegetation. It was a gratification to know that the vehicle went in the direction of their home.

"George is safe; I am sure of that."

"Why do you think so?"

"Because he has been eating nuts; see the shells scattered along here and there?"

Following the course of the wagon they would occasionally lose the trail, but they were satisfied that George was on his way home.

Before reaching home they saw George coming toward them in great excitement, and a little be-

yond was the wreck of the wagon, with nuts, ore and other accumulations scattered along the ground.

"What does all this mean?" said the Professor.

"I don't know; a little over an hour ago there was an explosion which so frightened the yaks that they ran away, and you see what they have done to the wagon."

"But where have you been? I hunted for you everywhere, and then went after the Professor. We have been up there after you."

"What is all this you have on your clothing?" said the Professor, as he examined the back and sides of George, whose clothing was covered with a slime of brown-colored material.

"Got it where I fell. I had the breath knocked out of me when I went down in the hole."

"A hole?"

"Yes; a hole about 15 feet deep, on the side of the hill, not 500 feet from the wagon. When I got out I staggered around for a while, and when I reached the wagon Harry wasn't there, and as I then knew I must have been down there quite a while, when I couldn't find Harry, I made up my mind the best thing to do was to go home. When we reached that point over the hill, I heard an awful explosion, and you see the result."

CHAPTER XIV

THE DISAPPEARANCE OF THE BOAT

The Professor and Harry laughed at the situation, but George was still troubled at the explosion, and the Professor soon enlightened him to his great relief.

When they reached home the yaks were there, still yoked together; before nightfall they had repaired the wagon and hauled in the store of nuts, and some of the ore, which could be gathered up.

"George, tell me how that hole was formed? Did it appear to be dug out of the side of the hill, or was it simply a hole that went straight down into the ground?"

"Well, I didn't have much trouble in getting out of it. A thick growth of bushes was all around the hole, and when I pushed my way through I went down before I knew what was happening. The first thing I remembered was a feeling of dizziness, and then I recalled the bush. I think the hole went in from the side of the hill."

"Did you see any rocks in the hole?"

"Yes; there were rocks on the sides, but I did not see any in the bottom part. The stuff you see on me was at the bottom and on one of the sides of it."

"What do you think it is, Professor?"

"Asphaltum."

"What does it come from?"

"Petroleum, after the volatile matter has evaporated from it. You are really a discoverer, George, and it is a lucky find."

"Well, I seem to be having a pretty tough time discovering things. I suppose that is the lot of the investigator?"

"Some of the greatest discoveries have come about by accident. The accidental breaking of a wire was the means of discovering that light contact points in a telephone circuit would amplify sounds, so that the transmitter was made possible; the experiment that I asked George to make with the hair in his shoes, was the accidental discovery of St. Gregory, a monk, who used hair in the bottom of his sandals to protect his feet; a chicken's feet, covered with clay, tramping over a bed of brown sugar, showed a way in which sugar could be bleached, or whitened. Hundreds of such instances might be cited."

It did not need any inquiry on the part of the boys to tell them what the Professor had been doing in the hills that day. He had made a sample of powder, and while the boys were nutting he was at the coal bank trying to loosen up coal for their use and, also, incidentally, trying out the powder. That it succeeded, all had sufficient evidence.

Over and over again the Professor questioned George about the hole. From his tone and the interest he manifested in it there was something, evidently, which he did not care to mention.

The next morning Harry abruptly said: "We

have forgotten all about our boat; we ought to go for it at once."

Such was the fact. They had been so busy every moment of the time that if either thought of it no sign was made. True, they had no occasion to use it, but as soon as Harry spoke all agreed to the wisdom of securing it.

"I think both of you had better go for it at once. It has cost us too much labor to lose."

Preparations were soon made, and the Professor gave full instructions as to the course to pursue.

"If you follow my advice you cannot miss the river. From my observations, the South River flows due west, or nearly so, to the falls, where you will find the boat. Look at the sun. It is now nearly nine o'clock, and note the shadow, which, as you see, falls to the southwest. It is about ten miles to the river, and, probably, fifteen miles to the falls. Now, mark your course so that it is at a certain angle to the shadow. In an hour, as the sun then throws a shadow farther south, alter your course, with relation to the shadow, and so on each hour, which will bring you to the river between twelve and one o'clock. At the river you can readily trace it up to the falls.

Two sprightly boys, on a clear, bracing day, can easily make three miles an hour, unless the ground is too rough or uneven, and the river was reached about noon. Before two o'clock the falls were sighted. The sail down the river would give them a rest after the long tramp, so with shouts of laughter, they gaily ran along the bank to the boat's landing place.

The boat was not there!

Visions of the fire, the missing pole and flag, and the black hole came up before them. Both thought, but neither uttered their fears. There was not the slightest trace of the boat. The beach or bank did not indicate that the boat had been dragged off, and question after question was asked and the probabilities canvassed.

"I suppose the only thing we can do is to go home, which can be reached before six this evening, if we hurry." They turned to go and had but proceeded a hundred feet when George stopped. "Do you remember where the oars were when we left the boat?"

"Oh, I had forgotten; the Professor told me to place them up against the bank, and I pushed them in among the roots of the tree where the stream had washed the dirt away."

With one mind, they returned; but even the oars had disappeared. This was too much for them, and there was no further waiting for discussions. Tired as they were, they turned for home, which was reached as the sun was going down.

"Do you think our boat was taken by the natives?" inquired Harry.

"Before answering that question I should like to know how the boat was secured," replied the Professor.

"It was drawn up on the beach, as you directed, and tied to a tree which hung over the river."

"How high up on the bank were the oars placed?"

"About five feet above the boat, under the overhanging bank, among the roots of the tree, as you said that would be a good place."

"Did you notice whether there were any marks where the rope was tied to the tree?"

"No."

"Did you carefully examine the river on both sides coming back?"

"No."

"I have a theory, but it is only a theory now."

"And what is that?"

"We have had considerable rain lately, and the South River, being fed by mountain streams, may have been up pretty well, so that our boat and oars were carried away."

"That seems probable, but it is singular that both the oars and the boat are gone, because I fixed them securely, as I thought, in the roots of the tree. The boat may have been discovered and used by some one on the island."

"But if so they would have to use it below the falls."

"Yes; unless they carried it around the falls and are now using it on the river above the falls."

Notwithstanding the several mysterious things which had occurred during the past month, the Professor, while he showed interest in discussing the situations and the problems which grew out of them, was not at all perturbed. He showed merely the spirit of the true investigator.

During one of their regular evening discussions, he said: "No doubt you have been very much disturbed at the interesting events which have come

into our lives lately. These things, though they may be startling episodes, are not unusual events in every walk of life. The investigator in every branch of human activity discovers something only to find out a mystery beyond that which he has unraveled. The more he knows the greater are the mysteries. Patient investigation solves some of them; accidents reveal the hidden secrets of others. If man must know things, he must also learn to look philosophically at those things which are, apparently, beyond his grasp."

"For my part," answered George, "these mysterious occurrences only make me more eager to continue our work. What I am anxious to know is, what line of work we should follow to make us more secure, now that we are pretty sure there are others on the island?"

"We should, if possible, spend our energies, as Harry has suggested, to the making of weapons, although I hope it is not done for the purpose of being able to become the aggressors."

"For my part, I should like to make some guns."

"Harry's idea is all right. Guns are necessary. It is also prudent to add to our stock of provisions, especially as the wet season is coming on, and we do not yet know how cold it will be. These two things are most essential for our welfare. I would also suggest that hereafter, in making any excursions in the interior, at least two should be in the party, so as to be of mutual assistance."

Harry's lathe, on which he had devoted all his energies, was finally completed, except the tool-holder, which, under the advice of the Professor,

was made of a block of hard wood, with a T-shaped attachment, the vertical limb of the T being made to fit snugly between the two parallel bars of the frame. To this T-shaped leg they attached a heavy stone, so that the tool block, or holder, thus made could be moved along, and carry the stone with it.

They then provided a means for moving it along on the bed, by attaching a rope to each side and wrapping it around a rod which had a crank on it, and by that means the tool could be moved along and held firmly against the metal to be turned.

It must be said that the tool was not an accurate one, nor could they turn the hard steel metal with it, but it was available for and could take off the rough cuts on the metal, and by attaching a grindstone to the tool-holder, they soon found a means whereby it would turn down the annealed steel bars. With this crude beginning the first work was to turn up a half dozen round bars of steel. Each was three-quarters of an inch in diameter, and from eight to ten inches long, which they finished off with the grindstone.

The next step was to make some drilling bits, which was not a difficult task. One bit was made which would bore a hole three-quarters of an inch in diameter and another bit for a half-inch hole.

Fortunately, the mandrel had not been tempered, after the brazing process, so Harry was instructed to drill a hole in the end of the shaft. This was done by holding the three-quarter bit rigidly in the tail stock of the lathe.

The hole in the end of the shaft was then used to hold the half-inch bit and they were ready to bore out the half dozen round bars or barrels. This work occupied days of time. Harry meanwhile made smaller drills for use on other work.

George was always inquisitive and suggesting or questioning, and one day explained to Harry that if they had some means of accurately finding out the time it would be very much use to them. Of course, the Professor was brought into the consultation.

"Do you know, boys, how we can get the exact interval of time? That is, how would you go about the business of finding out just how long one minute is?"

"I know; there are twenty-four hours in a day, and it would be an easy matter to divide each hour into sixty minutes."

"That is a good suggestion, but in the meantime we should have some mechanical means to indicate the time that is passing, and if that goes too slow or too fast we can regulate it."

"Yes; we might use an hour-glass, as I have read, or we might make a clock."

"A clock would be much better, so if Harry will make a small wheel, say two inches in diameter, and cut thirty teeth in it, we can make a start."

"Then we must also have a pendulum, and while Harry is making the wheel I'll make that. How long must it be?"

"At Greenwich, England, which is about latitude 51½ degrees north, if a pendulum is thirty-

nine and one-eighth of an inch long, it will vibrate once each second."

"What has the latitude to do with the length of the pendulum?"

"The beat of the pendulum depends upon the pull of gravity, and as a body weighs more at the poles than at the equator, the length of the boat will not be the same at different points from the equator."

"Are we as far south of the equator as Greenwich is north of it?"

"No; I think we are probably a thousand miles nearer the equator."

"Then must I make the pendulum longer?"

"No; shorter, so it will beat quicker."

It was agreed to devote at least a day each week to making trips into the island, so as to give variety to their lives, also to learn as much as possible about the country. Now that they had a reliable team of oxen, journeys could be made with comparative ease. The wagon had been greatly improved, by making lighter wheels, without in the least sacrificing strength, by using a greater quantity of metal.

Not much anxiety was exhibited to penetrate far into the interior because they had not yet anything more effective than bows and arrows as weapons of defense.

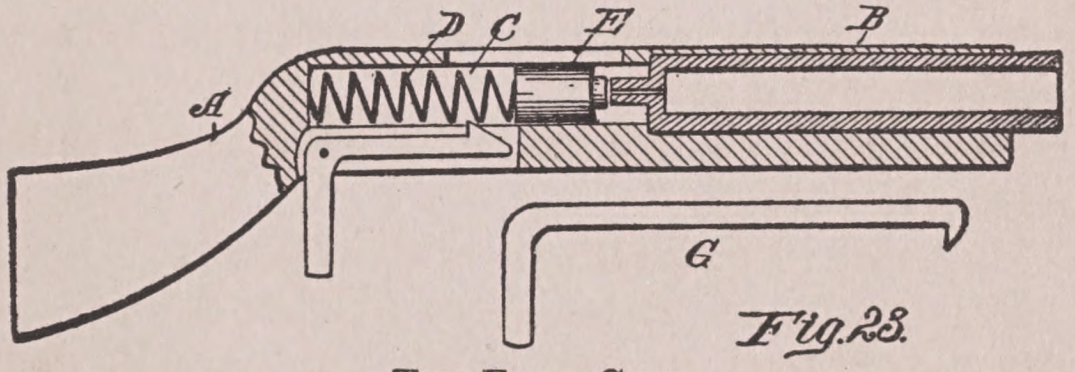
Harry succeeded, however, in finally drilling out the six barrels of steel, and with the small drill bored a hole at what is called the breech, or rear end of each barrel, and the drawing shows how simply they formed the barrel and the little

tube on which they intended to put the cap for firing.

"We are now ready for the caps, Professor," said Harry one day.

"Have you all the stocks completed?"

"Yes; George has whittled out the wooden pieces, but I am a little troubled to know just how we can make a hammer on that long wooden stock?"



THE FIRST GUN

"I see you have bored out the stock (A) so the barrel (B) will fit in, and that the hole (C) back of the barrel is a little smaller. How did you succeed in forging out and tempering a wire for the spring (D), as I showed in the drawing?"

"Here it is. It may be a little stiff."

"If it is, we can shorten it and then make the hammer plug (E) a little longer."

"What I want to know is, how to draw back the plug or hammer so the hook of the trigger will catch it?"

"For the present that is what the hook (G) is for."

"Oh, I see it now."

"I am pleased to see the workmanlike manner in which you have accomplished all this. You are

to be commended for this reason: Any mechanic can turn out a product with tools; the genius lies in being able to make things without proper tools."

"Oh, yes, we must have some percussion caps. George, how do you think we can make them?"

"From what I understand in the making of matches we could use sulphur and phosphorus to put in the cap."

"Yes, and in this case we should mix some very fine sharp sand with it."

"What is that for?"

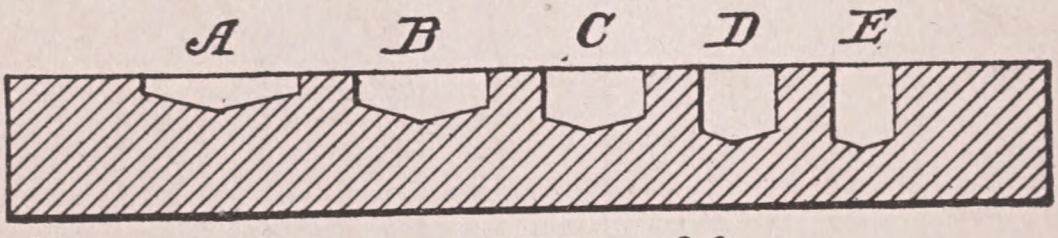


Fig. 24.

CAP-MAKING DIE

"So when the hammer strikes the cap it will crush the sand, or rather cause the sand to force its way through the compound, and in that way, by friction, make enough heat to cause an explosion."

George made a number of caps out of the native copper, which, of course, was very soft, and to do this the copper was beaten into thin sheets, and then the Professor instructed them how to make the caps. A piece of steel was used in which they drilled five holes. Figure 24 shows the Professor's drawings.

The first hole (A) was made with a three-quarter bit, and was very shallow; the second (B) with a five-eighth bit, and a little deeper; the third with a half-inch bit, and still deeper; the fourth with a

three-eighth bit, and still a little deeper. The last hole (E) was made only a trifle smaller than D, but, of course, deeper.

"Now make your punches, as I show in Figure 25, one for each hole, smaller, of course, than the holes. To punch out the caps, lay a sheet of copper on the hole A, and drive punch A down into it with a hammer; then put the sheet so punched on the next hole (B), and use the punch B′, and so on. After the last hole (E) has been widened

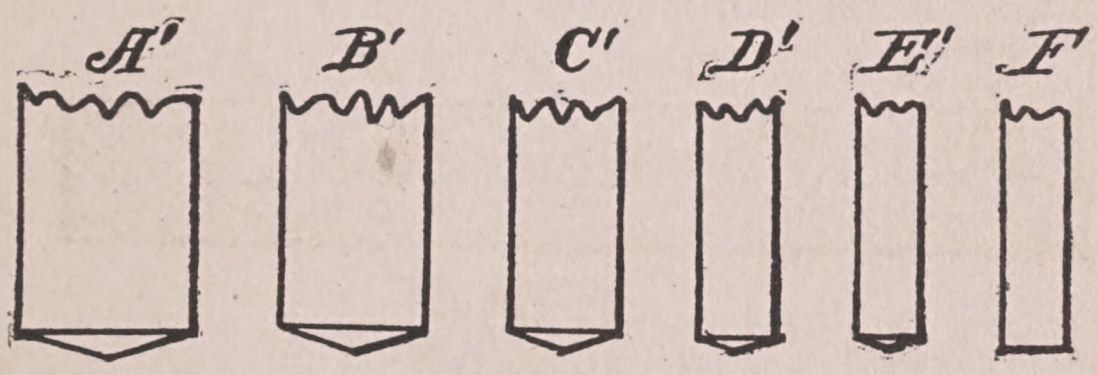


Fig. 25.

PUNCHES FOR DIES

use a square-ended punch (F′) so that the bottom of the cap, when completed, will be flat."

The work of putting the fulminate in the caps and drying them did not take long, and the Professor brought out a sample of the powder which he had made, and which was used in the experimental explosion at the coal bank. There was, probably, two pounds of it.

For several days more they worked hard to complete their firearms, and when the first one was finished they could not restrain themselves, so eager were they to try the first shot.

And now came the question of bullets. They had forgotten this really important part of the equipment. They had no lead, although there were samples of blende ore which the Professor thought would yield some of the metal, but the experiment had failed.

"Why is it, Professor, that you did not succeed in getting the lead out of the ore we found?"

"The difficulty is that lead is not generally found in a native state, or as free lead. It is usually in the form of an ore, called Galena, which is the sulphide of lead, so it is difficult to recover without the proper chemicals and treatment. Lately native lead has been found, and we may yet get some samples."

"Then what shall we use? Is there any reason why we cannot make the bullets out of iron?"

"They will answer, but are not as good as lead."

"Why are they not just as good as lead?"

"Because momentum, as it is called, is an important thing in a bullet. If, when riding in a car, it suddenly stops, momentum is what tries to carry you on. So with a bullet—the heavier it is the greater is the momentum. It would be much better, also, to make the bullet long, and pointed at the end."

It was necessary, therefore, to make iron bullets, of which they turned out four dozen. This work occupied several days of their time.

And now it may be interesting to look for a little time into the daily lives of our colonists, so that we may be able to know how they lived, and what their fare was. They still had a supply

of honey, which served them well, as a substitute for sugar.

"Isn't honey the same as sugar?"

"It has many of the properties of sugar, but it is not wholly vegetable, even though made from vegetables, such as flowers."

"Wherein does it differ from sugar?"

"Sugar is a purely vegetable compound, but in the case of honey, it passes from the sucking tube of the bee into the sucking stomach or honey bag, where it is transformed into a kind of animal compound."

"What makes it so sticky?"

"It has mucilage in it. Melted sugar and mucilage act like honey, even though it doesn't taste like it. Sugar is not as sweet as honey."

"Is honey found everywhere?"

"Yes; in every part of the world, except in excessively cold climates. It was man's original food."

"It was pretty nearly the first kind we had."

Then, besides the honey, were the potatoes, several kinds and a variety of sweet potato, and cassava; and for flour they depended mostly on the sago tree, a supply of this being one of the chief requirements by all of them. Nuts in profusion, enough to delight the heart of any boy. Barley was now coming in and it was getting more plentiful.

One day Harry said: "I notice that the yaks cross the river every day at the lower ford, and return again in two or three hours. I wonder where they go?"

"Evidently they know the best feeding ground. Suppose we investigate the matter?"

It happened that during the entire time they were on the island they had not followed the line of the cliffs to the west. The Cataract house was less than a half mile from the sea, or from the cliffs, and the altitude of their home was, probably, 75 feet or more, whereas the cliffs were higher, and particularly that prominent point which they called Observation Hill, was fully 125 feet high.

Directly to the west, in the unexplored part of the island, and north of the forests, was the part visited by the yaks.

George and Harry took their guns next morning and followed the yaks up the incline beyond the Cataract fully two miles, where they emerged on a lower plane, shut out from the sea, although they could still see the line of cliffs beyond. Here, to their surprise, was a fertile field of barley, an abundance of the cereal being found in all directions.

"This looks like a cultivated field of barley, it is so evenly distributed."

"If it isn't cultivated I wonder why it grows in this way? That isn't our herd; look over there."

On the opposite side of the field from their yaks were dozens of the animals eating the luxurious growth.

"No wonder the yaks have been visiting this section. While we are here let us visit the cliffs. I want to look at the sea from this part of the land."

Their steps were directed toward the nearest point, and when the last line of rocks was reached

the sea was in sight. The water, however, did not come up close to the base of the cliffs, there being a rocky beach intervening. This was covered with driftwood, trees, seaweed, and debris such as is usually found on beaches everywhere.

Here, before descending, was the first opportunity to try their guns. George was fortunate enough to shoot a partridge, which, however, was purely accidental, as he excitedly fired into an immense flock, killing one and wounding another, which they finally captured.

The beach with its wreckage was an interesting sight. They followed the course of the cliffs back toward the Cataract, hoping to be able to reach the mouth of the river without again ascending the cliffs.

After proceeding a half mile Harry's attention was directed toward an object among a mass or debris, which had a red color. It was about two feet long, slightly curved from end to end, and was provided with a rib at one edge. The other edge was jagged and the ends broken off abruptly. It was undoubtedly a board, or a part of a ship or boat. There was no indication of decay at the broken edges of the board. The rib was the portion painted red, and the other part as a dark brown.

"Let us take it down to the Professor. This may be important to us."

"Wait," said George. "The Professor will ask us all sorts of questions about the place, and how and in what condition it was found, so let us be prepared."

To their gratification they were able to reach

the river without climbing back over the hills, and it was a pair of excited boys who met the Professor.

"Another find," was Harry's first remark. They found the Professor at the water wheel dislodging a small trunk of a tree which had caught in the propeller.

"And what is that?" asked the Professor, eyeing the red board.

"We think it is a piece of a boat, and it just occurs to me that it might be a piece of our own boat."

"No," was the Professor's response; "our boat had no red, if you will remember. This is no doubt the gunwale of a ship's boat. Was it lying under the debris?"

"No, we found it almost on top."

"What else did you find around it, or in close proximity?"

"Nothing; we didn't search very far after we found this."

"How high up on the bank was it?"

"About fifty feet from the water's edge."

"What puzzles me as much as does the finding of this piece of the boat, is to know why it is that an island like this should have so much drift-wood on the shore. We haven't seen any trees growing near the shore."

"Have you thought of the rivers?"

For a moment the boys pondered.

"The piece I took from the water-wheel when you came up was pretty good evidence as to the medium which supplies the beaches."

CHAPTER XV

PLANNING THE SECOND EXPEDITION

But we had entirely forgotten the description of their daily life. Early each morning it was the Professor's habit to arise and build a fire for the morning meal. Let us describe the meal. Yak's milk was one of the principal items; then there was always a supply of the most delicious tapioca, or barley, now that the crop was ripening. Quinces had been found, as stated heretofore, and those were cooked and with the honey made up into a delicious preserve. They had found no apples, but berries were abundant everywhere, alongside the hillsides and in the valleys along the streams.

They longed for some bread—real home-made bread—and visions of the barley fields haunted them. They looked so much like the wheat on the farms at home. Harry, as usual, when it came to the question of provender, was the first to express himself.

"I am in favor of taking a lot of the barley."

The Professor was much interested in the proposal. "Why not make barley flour?"

"I never heard of it. Do you think it will make a good flour?"

"Nothing better. It is a cereal which is more widely known, and more generally grown, over the surface of the globe than any other. It grows

in Lapland as far as 70 degrees latitude, and at altitudes of over 10,000 feet in the Andes and in the Himalayas. It is not as palatable as wheat, and not as nutritious, and it retains its husks more closely."

"Why can't we rig up a flour mill?"

"That is a good idea, Harry; but before doing that a scythe would be a good thing."

Here was the next article to make, and Harry set to work at once.

George also took a keen interest in the proceedings now.

"While Harry is at the scythe, I will make the hay-rack for the wagon, so we can make the first trip to-morrow."

The noonday meal usually consisted of meat, and frequently of fish, of which they had several varieties. Game had been a scarce commodity with them on account of the difficulty in bringing them down with the bows, but the guns made a change in this direction also, and besides partridges, they found grouse, and also prairie chicken, the latter the most delicious of all. In addition there was an ample supply of "corned beef," which was sparingly used, at this time of the year, and only by way of variety.

The evening meal was a substantial one, as the vigorous work made them ravenous, and they ate as only boys of their age can eat under the circumstances.

The following day the boys were ready early, fully equipped with a scythe, a rake and a pair of forks (the latter being made of wood), prepared

to make a day of it, and bring back as big loads as they could handle.

In about an hour they reached the barley field, and the boys, both fresh from farm life at home, did not need instructions in the handling of the scythe, at which they took turns, and to the delight of the boys, the Professor showed his skill as well.

"Shall we cut it high and remove only the heads, or take as much straw as possible?"

George and the Professor both favored taking all the straw possible, as they needed good bedding, and in addition it would be a fine thing to provide their yaks with a supply.

"If we have any left we might make some paper," was the Professor's comment.

"What, out of barley straw?"

"Certainly; it will make a good paper. All wrapping papers were originally made entirely of wheat and barley straw."

"I have an idea that we might thatch our roof with it."

"Capital; but we should have cradled the barley, instead of cutting it with a scythe, to keep the stalks straight."

The boys, as you see, both had the idea of utility in all their enterprises, and, after all, what are the good things of the earth for if not for the purpose of contributing to our support and comfort?

"How much will our wagon hold?"

"With the kind of roads we have I do not think we ought to take over half a ton at a time."

When they had completed their last load, George

thought they had cut fully an acre, but Harry disputed it, and the Professor suggested that the space cut be measured, so the acreage could be determined.

"Even if we do measure it off, how can we ascertain just how much of an acre we have?"

"One square acre contains 43,560 square feet, so that about 209 feet wide and the same in length, would make an acre."

When measured the space cut was found to be approximately 170 x 130 feet, which would be 22,500 square feet, or a little over a half acre. When they reached home the question of weight troubled the boys. Up to this time they had no occasion to make such calculations necessary.

"How are we going to make a pound measure?"

"We need distilled water, and a measuring rule for that, and, of course, we should also be in the latitude of Greenwich, England, and conduct the experiment in a temperature of 62 degrees, to make it absolutely accurate."

The boys laughed at this, as it might be imagined they would.

"It's too funny, to think we have to go way over to England to find out how much a pound weight is. Why should all those things be necessary?"

"For these reasons: Distilled water weighs less than undistilled. But distilled water is used because its weight is something definite. Water not distilled may have different substances in it, dependent upon the kind of water it is, and so weigh more or less. The pull of gravity, as you have learned, is different at different points from the

equator, and by selecting a temperature of 62 degrees we are measuring in a known displacement or weight of air."

"For our purposes cannot we take the cataract water and get the measure from that which will be near enough?"

"Certainly; bring a pint here, and make it as exact as possible."

Again the boys laughed. "We don't know how much a pint is, either."

The Professor joined in the laugh. "Quite true; I had forgotten. A pint is 27 cubic inches. It is not that exactly, but we cannot be too particular, without very fine measuring instruments."

"Oh, yes; three inches by three inches by three inches make 27 cubic inches, and from the pint we can get the gallon or bushel."

When the necessary weighing machine was completed the half acre was found to yield 1,120 pounds of barley straw and all. During the next few days they were diligent in harvesting quite a crop, so that the storehouse contained several tons, awaiting the day for threshing out the grain.

During all this interesting work the boys could not longer resist the temptation to extend their knowledge of the island. It was like a loadstone, drawing them to the interior. Furthermore, they now had some firearms, which, though crude, would be very serviceable in defense and useful in hunting.

In the experiments with the iron bullets it was found that they could hit a mark fairly well at 150 feet, and when shot was used they could do

good execution at 100 feet, so it will be seen they could not depend on a long range. But with six weapons of this character, the longest of which had a barrel with a bore ten inches long, they had a pretty strong battery of guns. All were muzzle-loaders, since it was a difficult matter for them at this time to make cartridge shells, but they hoped to do that later on, as Harry explained.

The pistols, however, afforded them a sense of security which they had never before experienced. Notwithstanding their eagerness to start the Professor prevented an early departure, as he thought another week should be put in at home devoted to laying in additional stores for future needs, and in the meantime Harry could also make more of the guns, as they delighted to call them.

All concurred in this view. The boys were beginning to be practical. Necessity made them so. The contemplated expedition was to be a thorough one, and preparations were made accordingly. They might be absent a month or more, and it would be prudent to take along a sufficient quantity of certain supplies to last a full month.

Before going, however, one thing appealed to the boys. They must have some flour—real flour—even though it was only barley. A pair of milling stones had to be provided; but they were fortunate in having a good quality of millstone grit, which was taken from the hill they discovered on the second day of their arrival on the island. It was the same kind of stone they had been using for their grindstones.

Two fairly flat stones were selected, each about

two feet in diameter, and six inches thick, and one was placed on the other, the upper one being so connected up with the water wheel that it turned on the lower one, and in that way the two faces were ground off, so the surfaces of both stones were flat. This required a full half day to do.

A hole was then drilled through the upper one, and a metal piece was put centrally in the lower one, so that the metal piece could be raised or lowered an inch or two. A hole was also drilled in this metal piece, and it then formed a seat for the spindle which was secured in the big hole in the upper stone. A framework was built up and a crosspiece put above the upper stone, so the spindle of the upper revolving stone could be held in position, and this upper spindle had a small pulley so a belt could be run from the large pulley of the water-wheel shaft, and thus turn the upper stone.

As the metal seat in the lower stone was made to move up or down, the upper stone could be adjusted so as to run close to the lower stone, and thus grind the barley very fine.

The Professor explained that in stones, as usually made, the practice was to form radial grooves in the contact faces of the stones, but by using a very coarse stone, which he had purposely selected, this was not necessary. All primitive grindstones were used without grooves, but ingenious man found that the grooves improved the stones and that they could thereby use a finer quality of stone, and by that means make a finer flour.

"Millers don't use grindstones any more now, do they?"

"No; the march of improvements has been taking in the milling process, as in everything else. What is called the roller method of grinding, does not require stones, but metal rollers instead. It will be interesting to put up a small mill of that kind when we return."

"Now that we have made a success in grinding, how can we take out the bran?"

"The loosely woven ramie cloth will answer, in the absence of bolting cloth."

The bolting of the flour was attempted, but it was not very successful, as the samples turned out carried quite a quantity of fine bran, or middlings, as it is called.

The kitchen utensils comprised the following articles, some of which were of soft copper and others of iron: Two iron vessels for boiling or cooking purposes, one smaller boiler, three cups, three knives and forks, a few plates and spoons. Quite an array for housekeeping purposes.

Aside from this there were other metal receptacles, in one of which they kept their supply of honey, of which they still had a good supply. In several bags were potatoes and cassavas. No nuts were taken on the journey because they could be found everywhere. A number of fiber bags were also made, these to hold such samples as might be found on the journey, and which were used at this time to put their food in. Lastly, at George's suggestion, they made a small stove with an open bottom, and provided with two holes in

the top, on which the cooking vessels could be placed, as such an arrangement conserves the heat of the fire and also keeps the smoke away from the cooking utensils, and when fitted up with a chimney, as George planned, the smoke could be conducted up alongside the wagon top.

The boys, always jolly, and with an eye to the utilization of every incident, named their team Jack and Jill, in view of the runaway incident of the yaks at the time of the explosion.

Jack was a beautiful animal, of a dark gray color, and very docile. Jill was smaller, and had a reddish color. She was naturally restive, and no doubt had induced Jack to cause the smash-up several weeks before. The greatest caution had to be taken properly to tether and hobble Jill, but this was not necessary with Jack.

Both animals were less than two years old, just at an age when they could be best trained, as they were not yet fully grown.

The utmost dependence could be put upon the yaks, as during the harvesting season the team saw a herd of wild yaks at close quarters, but were not at all disturbed. They also had become quite accustomed to the noise of the firearms. Indeed, the thing the yaks most craved was food, and plenty of it; when that was supplied they had the most tractable team imaginable. The boys learned this during the first weeks of the training days.

"Well, boys, if we have everything in shape we might make a start to-morrow."

"I don't know of anything more that we can

do," was George's report, as he was really the active commissary.

Harry had prepared the ammunition, and each of the boys, as well as the Professor, carried two revolvers—they were really little guns, however. The barrels of all but one, which they called the Hercules, were eight inches long, and with the stock were two feet long, so they had straps prepared, to which they could attach the guns and hang two of them from their shoulders. Each also had a bolo, and, as stated in a previous chapter, they had several spears, which were kept in a set of keepers below the body of the wagon so they could readily be found in case of necessity.

The new wagon had been enlarged, so that it was wider; and one of the first things done was to weave a top for it when it was completed, so that it really formed a tent for the vehicle.

Near the rear end of the wagon bed was the stove, and a small detachable pipe led up past the top, so they could, in case of rain, do their cooking without leaving the wagon.

On other occasions, when the weather permitted, the stove was taken out and the cooking was done on the ground. All their provisions were stored in the bottom of the wagon bed, and the mattresses, which were now made up of the barley straw, were stood on edges on the opposite sides during the day, and were then arranged in the clear space during the night. Within the canvas top, which formed the tent, seats were provided, and also one for the driver in front, and one be-

hind, as the Professor suggested they should have a rear guard while traveling.

In the early training days of the yaks, they would guide themselves solely with the whip, in the well-known fashion; but as the yaks became more familiar and the boys learned how to handle them better, it was an easy matter to guide them by means of ropes attached to the stubby horn, so they could turn them to the right or left at will.

The question now was, where to go? There should be some definite course to follow. It was decided to go due west, pass by the barley fields, to the left, and skirt the forests on the north side, for at least fifty miles.

The Professor's great anxiety was to explore the region along the mountain range, but the difficulty was to cross the South River. It would not be wise to risk a transit on a raft.

Harry made the first observation concerning their course. "If we go directly west we shall, I am sure, get into the country where the savages are, which will not be the case, probably, if we go south."

"Then I am in favor of it," said George; "let us go for the savages. I want to know something about them."

Harry pondered a while. "I don't mind the savages. I am curious to know what we can find along the seashore, and for that reason I agree with the Professor to go due west."

It was with a great deal of satisfaction that they had completed all preparations and were now ready to start. The water wheel was rolled out

of its position, so that the blades did not touch the water. It would simply wear out to no purpose during their absence. The houses were carefully closed up, and everything put in order for a long stay. At nine in the morning the start was made.

The course adopted was constantly to have one of the boys on foot ahead of the team a sufficient distance to pick out a safe and easy route. The other two were to remain on the wagon; one to drive, and the other to act as a rear guard on the tail seat.

The yaks, while slow moving animals, are more active than the common ox, and could easily make from three to three and a half miles an hour, but on uneven roads the best they could expect was two and a half miles an hour, so that when they camped for the noonday meal between twelve and one o'clock, the distance traveled was about ten miles.

Little did either of the boys know what wonderful experiences and adventures lay before them, and many of them will be related in the next volume, "Exploring the Island."

THE END

A Part of
WONDER ISLAND.

1. The rock where they landed.
2. Harry's route to the shore.
3. Where Harry landed.
4. Where he launched his raft.
5. The first home.
6. George's river adventure.
7. Where Harry found George.
8. Cataract Falls.
9. Cataract House.
10. Route to forest.
11. Their first camp.
12. Adventure with the Bear.
13. Clay banks.
14. Slate shelves.
15. Iron and Coal.
16. South river.
17. Lost creek.
18. West river.
19. Observation Point.
20. Dense forests.

GLOSSARY OF WORDS

USED IN THE TEXT

Assimilated. To make like or similar to; to bring to the likeness with.

Arc. A portion of a circle or other curved line.

Arrow-root. A root which contains a large amount of starch.

Aardvark. The Dutch name for earth hog. A species of wild hog.

Anthracite. The hardest coal. Usually burns without black smoke.

Anneal. The process of softening metal by heat.

Altitude. The height of an object, or its elevation above that plane to which the base is referred.

Astringent. Binding, contracting, strengthening. The name given to substances which contract and strengthen the animal fibers.

Adulterating. Corrupting or making impure.

Aggressor. The one who commences hostility.

Bacteria. A minute animal, or germ, which infects animals.

Blende. A sulphide of zinc.

Blaze. A term used to indicate marks made on trees to show a path or trail.

Bolting. In milling, the separation of the bran from the flour.

Bovine. The cow species of animal.

Braze. The soldering together of metals by the use of heat and a suitable flux.

Breech. The rear end of a firearm barrel.

Breakers. The heavy waves on a coast line.

Castanha. The Brazil nut.

Cannel. A variety of soft coal which burns with a bright flame.

Calcium. The technical term for lime.

Cassava. A tuber, of the potato variety.

Carbon. One of the four primary elements. A fuel.

Carbonic Acid. The gaseous product of carbon.

Calcined. A product which has been subjected to a heat for the purpose of driving out all gaseous matter. Roasting.

Caulk. To close up; to prevent leakage.

Circumferential. Around an object as a string wound around a cylinder.

Cleat. A piece of wood used either to hold together various parts, or, as used in maritime vessels, it is a small wood or metal projecting piece to which a rope is attached.

Charcoal. The residue or solid matter after the most volatile or the lightest part of the wood has been burnt out.

Collapsible. To fall together; shrinking; a wasting.

Corundum. A crystallized mineral substance, used for cutting and polishing purposes.

Concentrated. Brought together, or to a center.

Coke. The solid residue of coal after the volatile matter has been burnt out.

Combustion. The term used to designate anything burned or consumed by heat.

Conserving. To save; to preserve; to keep.

Cirrus. Clouds which are distinguished by fibers or curling streaks which diverge in all directions.

Cumulus. A cloud with large, convex, white-topped formation, and dark or black base.

Cylindrical. A long, circular body of uniform diameter.

Deft. Ready; spruce; smart.

Dextrous. Right-handed; ready; quick.

Diagnosis. The art or method of determining diseases.

Drill. A tool for forming round holes.

Dynamo. An electrical machine for generating electricity.

Electromagnet. A device which comprises a bar, on which is wound a coil of wire to receive a current, and by means of which a magnet is formed of the bar.

Emery. Made up of hard substances, like the grit of precious stones, and used for cutting or polishing.

Elongated. Made longer in one direction than in the other.

Expansion. Enlarging; spreading out.

Fulling. A term used in the making of felt goods, which is done by putting the lightly matted felt in soapy water, and by beating or pounding, causing the fibers the more closely to move together and thus make a firmer cloth.

Fissure. A cleft in a rock, or earth formation.

Flux. An ingredient, like borax, which is used to facilitate the unity of metals in the process of welding or brazing.

Formation. The structure or arrangement of the various parts of mechanism, or rocks, or earth, or other substances.

Flume. A trough or conduit which serves as a means for conveying water to a power wheel.

Fluxed. A metal which, when melted, is united by means of some element.

Fuses. The term applied to a metal which is brought to a molten state.

Function. An attribute of anything which shows what it will do or is capable of performing.

Fulminate. A compound which will readily ignite by heat or friction.

Germ. A minute animal, found in all animal and vegetable matter, which rapidly grows and develops.

Germinate. The act of growing or increasing.

Gravity. The attraction of a mass for another mass of any kind of material, like the attraction of the earth.

Gunwale. The lengthwise strip covering the upper end of the framing timbers of a boat.

Gunny Bag. A coarse, heavy sacking of jute or hemp for wrapping cotton bales or for making bagging.

Half Mast. The position of a flag when hoisted halfway up the mast, as a tribute of respect or as a signal of distress.

Hydrogen. One of the four elements; the lightest of all substances.

Heddle. A series of vertical cords or wires, each having an eye midway between its ends, through which the warps are threaded.

Incorporated. Bringing together in an orderly form. Intimately mixing various ingredients.

Induction. That quality in electricity which causes a current to pass through the air from one wire to another.

Ingot. A bar of metal, usually containing the crude or unrefined material. In a general sense, a piece of metal.

Intractable. Difficult to manage. Not easily handled.

Laboratory. A shop where tools and implements, or chemicals and instruments, are used to make experiments.

Ligament. A strong, flexible muscle, which forms the juncture between the bones, or which may be used as a binding.

Lignite. One of the coals, usually regarded as an incompletely formed coal.

Life Buoy. A float to sustain one or more persons in the water.

Locker. A compartment in a boat, or other space, which can be secured by a lock or otherwise.

Machete. A heavy cutlass used by many primitive tribes.

Mandrel. A short shaft or spindle.

Malleable. Not hard; softer than the usual composition of a metal.

Merge. To pass into. To become a part of.

Mercury. A silver-white metallic element. Quicksilver.

Meridian. The time when the sun crosses the highest point in passing from sunrise to sunset.

Metric. A system of weights and measurements which is dependent on the meter. A meter is 39⅓ inches.

Mica. Isinglass. A transparent earth formed from silicate.

Milling Machine. A machine having usually a horizontal spindle, which carries one or more metal-cutting saws for cutting grooves or surfacing material.

Momentum. The power of overcoming resistance possessed by a body by reason of its motion.

Neutral. Neither. Intermediate; between.

Nimbus. A dark, heavy cloud from which rain is likely to be discharged or from which rain is falling.

Nitrogen. A tasteless, colorless and odorless gaseous element, as in the air and in all plant life. One of the four prime elements.

Oakum. A fiber made from the coarse part of jute and hemp.

Oscillation. That motion which is made back and forth in either direction, like the swinging of a pendulum.

Out-cropping. The term, usually employed in mining, which designates the appearance of different veins.

Oxygen. A colorless, tasteless and inodorous element; the most abundant gas so far discovered, and the most important.

Palatable. Tasty; fit for food.

Penstock. The reservoir or enclosed portion connected with and which directly supplies the power wheel with water.

Perturbed. To be disturbed or annoyed.

Pitman. The rod which connects the crank with the other mechanical part.

Planer. A large power tool for surfacing or finishing lumber.

Potash. A white substance made from lye. Lye is produced by leaching water through common wood ashes.

Phosphorus. A soft, yellowish-white, non-metallic element which readily absorbs oxygen from the air.

Plumage. The coloring, the shape and form of bird's feathers.

Protuberence. A projection; an extension.

Primitive. The first; original.

Properties. The qualities or components of any substance.

Purgative. A cathartic; a purge.

Quill. The bobbin of a loom on which the woof thread is wound.

Ramie. A strong fibrous plant, resembling more or less all the qualities found in jute, hemp and flax.

Race-way. A chute for the movement of water.

Radial. Extending out from the center.

Recuperating. Recovering from an illness. Getting better.

Resultant. That which follows as a result of some movement.

Relaxed. To loosen; to make less firm.

Reverberate. Echoing; resounding.

Ruminating. Thinking; reflecting; considering.

Sago-palm. A tree from which a granulated sago is prepared.

Saponify. To convert a fat or oil into soap by means of an alkali.

Saturated. To soak with water or any liquid.

Serrated. Toothed. Provided with tooth-like forms.

Shale. A slate-like formation, midway in hardness between clay and slate.

Shaper. A power tool which carries a cutting tool on a reciprocating bed, the bed being so arranged that it may be adjusted at any desired angle.

Silicate. A white, hard material, found in the earth.

Solanum. The technical term for potato.

Spasmodic. At intervals; irregularly.

Shuttle. The moving spool in a loom which carries the woof thread.

Stock. The wooden part of a gun or pistol.

Stratus. One of the rain clouds, shown in the form of horizontal strips or streaks.

Staunchion. A standard or post.

Sterilized. Free from obnoxious and harmful germs.

Spindle. A slender spinning rod, such as is used in a spinning wheel.

Sulphur. A pale-yellow, non-metallic element, found in nature as one of the substances.

Sulphide. A compound of sulphur with a certain element, such as nitrogen.

Turbine. A water wheel turning on a vertical axis, and so made as to impart the greatest amount of energy to the wheel.

Tail-stock. That part of the lathe which holds the centering pin.

Tangential. The meeting point of a line or a surface at a point and then leaving without an intersection.

Taut. Tight. Hard-drawn; stretched tight.

Technicality. Specially pertaining to some art, trade, or occupation.

Tempering. The art of hardening metals by heat.

Tenacity. Toughness. The state or quality of being firm.

Texture. A peculiar or particular arrangement or structure of material.

Theorist. One who speculates on subjects, considering cause and effect.

Torpor. Apathy; sluggishness; partial insensibility.

Trophy. Anything taken from an enemy; a prize.

Triangle. A figure bounded by three sides and having three angles.

Tumble-weed. Any one of various plants which, on withering in the autumn, break away from the root and, having a more or less globular form, are driven about by the wind.

Venomous. Having poisonous substances, or poisonous glands.

Volatile. Matter which is dissipated by the action of heat.

Woodchuck. A grizzly gray animal, also known as the ground hog, which burrows in the ground. Of the rodent family.

THE "HOW-TO-DO-IT" BOOKS

CARPENTRY FOR BOYS

A book which treats, in a most practical and fascinating manner all subjects pertaining to the "King of Trades"; showing the care and use of tools; drawing; designing, and the laying out of work; the principles involved in the building of various kinds of structures, and the rudiments of architecture. It contains over two hundred and fifty illustrations made especially for this work, and includes also a complete glossary of the technical terms used in the art. The most comprehensive volume on this subject ever published for boys.

ELECTRICITY FOR BOYS

The author has adopted the unique plan of setting forth the fundamental principles in each phase of the science, and practically applying the work in the successive stages. It shows how the knowledge has been developed, and the reasons for the various phenomena, without using technical words so as to bring it within the compass of every boy. It has a complete glossary of terms, and is illustrated with two hundred original drawings.

PRACTICAL MECHANICS FOR BOYS

This book takes the beginner through a comprehensive series of practical shop work, in which the uses of tools, and the structure and handling of shop machinery are set forth; how they are utilized to perform the work, and the manner in which all dimensional work is carried out. Every subject is illustrated, and model building explained. It contains a glossary which comprises a new system of cross references, a feature that will prove a welcome departure in explaining subjects. Fully illustrated.

Price 60 cents per volume

THE NEW YORK BOOK COMPANY

147 FOURTH AVENUE NEW YORK

THE HICKORY RIDGE BOY SCOUTS

A SERIES OF BOOKS FOR BOYS

Which, in addition to the interesting boy scout stories by CAPTAIN ALAN DOUGLAS, Scoutmaster, contain articles on nature lore, native animals and a fund of other information pertaining to out-of-door life, that will appeal to the boy's love of the open

---

I. The Campfires of the Wolf Patrol

Their first camping experience affords the scouts splendid opportunities to use their recently acquired knowledge in a practical way. Elmer Chenoweth, a lad from the northwest woods, astonishes everyone by his familiarity with camp life. A clean, wholesome story every boy should read.

II. Woodcraft; or, How a Patrol Leader Made Good

This tale presents many stirring situations in which some of the boys are called upon to exercise all their ingenuity and unselfishness. A story filled with healthful excitement.

III. Pathfinder; or, The Missing Tenderfoot

Some mysteries are cleared up in a most unexpected way, greatly to the credit of our young friends. A variety of incidents follow fast, one after the other.

IV. Fast Nine; or, a Challenge From Fairfield

They show the same team-work here as when in camp. The description of the final game with the team of a rival town, and the outcome thereof, form a stirring narrative. One of the best baseball stories of recent years.

V. Great Hike; or, The Pride of The Khaki Troop

After weeks of preparation the scouts start out on their greatest undertaking. Their march takes them far from home, and the good-natured rivalry of the different patrols furnishes many interesting and amusing situations.

VI. Endurance Test; or, How Clear Grit Won the Day

Few stories "get" us more than illustrations of pluck in the face of apparent failure. Our heroes show the stuff they are made of and surprise their most ardent admirers. One of the best stories Captain Douglas has written.

Boy Scout Nature Lore to be Found in The Hickory Ridge Boy Scout Series

Wild Animals of the United States—Tracking—in Number I.
Trees and Wild Flowers of the United States in Number II.
Reptiles of the United States in Number III.
Fishes of the United States in Number IV.
Insects of the United States in Number V.
Birds of the United States in Number VI.

Cloth Binding *Cover Illustrations in Four Colors* *40c. Per Volume*

THE NEW YORK BOOK COMPANY
147 FOURTH AVENUE (near 14th St.) NEW YORK

THE

Campfire and Trail Series

1. In Camp on the Big Sunflower.
2. The Rivals of the Trail.
3. The Strange Cabin on Catamount Island.
4. Lost in the Great Dismal Swamp.
5. With Trapper Jim in the North Woods.
6. Caught in a Forest Fire.

By LAWRENCE J. LESLIE

A series of wholesome stories for boys told in an interesting way and appealing to their love of the open.

Each, 12mo. *Cloth.* *40 cents per volume*

THE NEW YORK BOOK COMPANY
147 FOURTH AVENUE
NEW YORK

Christy Mathewson's Book

A Ripping Good Baseball Story by One Who Knows the Game

This book has attained a larger sale than any baseball story ever published.

The narrative deals with the students of a large university and their baseball team, the members of which have names which enable the reader to recognize them as some of the foremost baseball stars of the day before their entrance into the major leagues.

One gains a very clear idea of "inside baseball" stripped of wearisome technicalities. The book is profusely illustrated throughout and contains also a number of plates showing the manner in which Mathewson throws his deceptive curves, together with brief description of each.

Cloth bound 5½ x 7⅝ *Price 50c. per volume*

THE NEW YORK BOOK COMPANY

147 FOURTH AVENUE NEW YORK

LIBRARY OF CONGRESS

00024889026